Conditioned Responses in Children

A Behavioral and Quantitative Critical Review of Experimental Studies

BY

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

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Introduction

1. The present review is the first of a series of comprehensive reviews of experiments on human and animal conditioning, from both Russian and non-Russian laboratories. These reviews differ from previous reviews of conditioning by Bekhterev, Pavlov, Beritoff, Ishlondsky, and Krasnogorski[1] and from other smaller summaries, however, not merely in scope but also, mainly, in the method of treatment of the material reviewed. First, they are behavioral in the sense that the facts of conditioning are treated as sets of variables of overt S–O–R modifications, with no concern for cerebral theories involved. The confusion of behavioral facts with cerebral theories has wrought havoc in the concept of conditioning. On the one hand, complex forms of personality and group behavior have been crassly over-simplified and uncritically accounted for by Russian reflexologists and their followers in terms of cerebral theories by no means established, often little warranted by the

[1] Bekhterev, V. M. *Ob'yektivnaya Psikhologia.* St. Petersb.: P. P. Soikin, 1907–1912. *Objektive Psychologie oder Psychoreflexologie.* Leipzig u. Berlin: B. G. Teubner, 1913, 468 p. *La psychologie objective.* Paris: F. Alcan, 1913, 478 p. *Obshchye Osnovy Refleksologii Cheloveka.* Moscow: GIZ, 1917. 2-d edition, rev., 1923, 408 p. 3-d edition, 1926, 423 p. 4th edition, rev., 1928, 544 p. *Algemeine Grundlagen der Reflexologie des Menschen.* Wien: F. Deuticke, 1926, 426 p.

Pavlov, I. P. *Dvadtzatil'yetniy Opyt Ob'yektivnovo Izucheniya Vysshey Nervnoy Deyatel'nosti (povedenya) Zhivotnikh. Ooslovnye Refleksy.* Moscow: GIZ, 1923, 244 p. 2-d edition, rev., 1924, 383 p. 3-d edition, 1925, 397 p. 4th edition, 1928, 388 p. *Die höchste Nerventätigkeit (das Verhalten) von Tieren. Bedingte Reflexe.* München: J. F. Bergman, 1926, 329. *Les réflexes conditionnels. Etude objective de l'activité nerveuse supérieure des animaux.* Paris: F. Alcan, 1927, 379 p. *Lectures on Conditioned Reflexes.* Twenty-five years of objective study of the higher nervous activity (behavior) of animals. New York: International, 1928, 414 p. *Lektzii o Rabotye Bol'shikh Polusharii Golovnovo Mozga.* Moscow: GIZ, 1927, 371 p. 2-d edition, 1927, 372 p. *Leçons sur l'activité du cortex cérébral.* Paris: Legrand, 1929, 418 p. *Conditioned Reflexes.* An investigation of the physiological activity of the cerebral cortex. Oxford, 1927, 430 p.

Beritoff, J. S. Über die individuell-erworbene Tätigkeit des Zentralnervensystems. *J. f. Psychol. u. Neurol.*, 1927, 33, 113–335.

Ishlondsky, N. E. *Neuropsyche und Gehirnrinde. Der Bedingte Reflex.* Berlin u. Wien: Urban u. Schwartzenberg, 1930, 328 p.

Krasnogorski, N. I. Bedingte und unbedingte Reflexe im Kindesalter und ihre Bedeutung für die Klinik. *Ergeb. d. inner. Mediz. u. Kinderhk.*, 1931, 39, 613–730.

basic facts of conditioning and contrary to generalizations suggested by investigations in fields other than conditioning. On the other hand, facts of conditioning have been at times plainly misunderstood and the rôle of the C–R as a principle of organismic modifiability inordinately criticised and unduly minimized by American and German psychologists because of the questionable reflexological theories. Secondly, the reviews are quantitative in so far as that all the pertinent statistical measures are computed from the data published. For, although the results of conditioning lend themselves readily to quantitative treatments, investigators in this field—with the exception of a few American experimenters—have glaringly failed to apply statistical methods to their data. Not only correlations and reliabilities but even simple measures of central tendencies and variabilities have scarcely been computed, conclusions being based very often upon single outstanding instances. Thirdly, the reviews are critical, pointing out the factors uncontrolled by the experimenters. Again, while the Russian laboratories—from which comes the major part of the experiments—are seemingly unsurpassed in their success in controlling secondary cues by highly perfected apparatus, surprisingly little attempt has been made in these laboratories to rule out extraneous factors by the use of equated control groups, rotation, timely interspersion of tests, and the like.

2. A behavioral review of conditioning also calls for the use of behavioral terms and thus necessitates considerable overhauling of Pavlovian terminology which is almost entirely based upon alleged cerebral mechanisms and which has not been really accepted even by a number of Russian experimenters. In order, however, not to multiply scientific vocabulary, full use will be made of descriptive terms used by previous writers, particularly by Beritoff. Inhibition and induction will of course not be used, since an adequate behavioral account of the facts of conditioning may be given without recourse to them and since, moreover, it is these very processes which are contested by those who do not subscribe to Pavlov's and Bekhterev's theories. *Conditioning stimulus* will be used instead of *unconditioned stimulus*, as the latter—besides its assumption—is unusably confusing in conditioning of higher order; similarly, *original response* will replace *unconditioned response*. *Unconditioning* will be employed in place of *extinction* for the recrement and final disappearance of a C–R upon repeated applications of the conditioned without the conditioning stimulus, while

generalization of conditioning or of unconditioning will denote respectively the appearance or the disappearance of a C–R to some stimulus without any training, and *transfer of conditioning or of unconditioning* will be restricted to cases in which, after one C–R is formed or unconditioned, another is formed or unconditioned with greater ease but not without additional training. *Negative conditioning* will supersede *conditioned inhibition* when, after a number of combinations of the conditioned without the conditioning stimulus but with some extra stimulus, the C–R is absent if the conditioned is applied with the extra stimulus but is still present if the conditioned stimulus is given alone. In differential conditioning, or when it is desired to form a C–R to some one stimulus but not to some other similar stimulus, the *positive stimulus* is the stimulus which is to be conditioned and which is as a rule applied together with the conditioning stimulus, while the *negative stimulus* is that which is to be differentiated and which is as a rule applied without the conditioning stimulus. Pavlov's use of *simultaneous* and *delayed C–Rs* will be retained, but Beritoff's term *successive C–R* will be used instead of *trace C–R* when there is a pause between the end of the application of the conditioned and the beginning of the application of the conditioning stimulus; conditioning of the second, the third, the fourth, and further orders will be used instead of secondary, tertiary, quaternary conditioning. In general, the selection of terms will be in accordance with simplicity and uniformity, and with no implication of cerebral mechanisms.

3. This particular review, which comprises all the experimental work on conditioning of children, is divided, for convenience, into six parts. I, Experiments from Krasnogorski's Laboratory; II, Experiments from Chuchmarev's and Lenz's Laboratories; III, Experiments from Ivanov-Smolensky's Laboratory; IV, Experiments from Bekhterev's Laboratory; V, Individual Experiments, both Russian and non-Russian; VI, Summary and Conclusions.

CHAPTER I

Experiments from Krasnogorski's Laboratory

4. The series of experiments of Krasnogorski and his pupils on conditioning of children correspond closely to the more numerous Pavlov series on dogs in both technique and methods used, in phases of conditioning studied, as well as in the treatment and interpretations of results. Pavlov's brain theories, typology, and terminology have been wholly taken over by Krasnogorski, while elementary quantitative treatment of results and adequate equated controls are apparently unwonted or unwanted in both laboratories. The highly perfected laboratories themselves do not differ fundamentally from each other, nor are there essential differences between the two laboratories in general methods used and types of problems studied. Improved accurate saliometers for children parallel artificial salivary fistulae in dogs, while the somewhat greater limitations of the work with children in general, such as necessarily shorter training series, forced interruptions when subjects become too refractory, discontinuance of some too extreme phase of conditioning for fear of ill effects, have been largely counterbalanced by Krasnogorski's recording of a greater number of effectors involved in each conditioning experiment. Diagrams of Krasnogorski's laboratory are given in the appendix, while the basic features of the laboratory as well as the gradual improvements in the indices of conditioning and in the techniques of their recording will be taken up here.

5. *Development of Krasnogorski's Laboratory and Technique.* In his pioneer experiments, in 1907, on conditioning the food response of a three-and-a-half-year-old child to the ringing of a bell, the index of conditioning was merely the comparison between the counts of the number of swallowings, in equal periods of time, when food was taken, when the conditioned bell was rung, and when no outside stimulus was given. But in 1908 Krasnogorski had already begun to take kymographic records of swallowings and mouth openings, at first by placing one tambour on the thyroid cartilage for recording the swallowings and another under the jawbone for recording the mouth openings, and later by attaching only one tambour between the jaw and hyoid bones for a combined record of the two responses. To these throat and mouth movements were recently added simultaneous kymographic recordings of the responses of the

skeletal muscles: movements of the fingers, elbows, and shoulder joints.

6. The systematic investigation of salivary C–Rs in children by means of suction cups, or saliometers, did not begin until 1926, although some elementary data had been gathered before by cementing a funnel to a natural parotid fistula of an eleven-year-old child. Originally the suction cups were essentially the same as the Lashley saliometers, though independently devised in Krasnogorski's laboratory, and could then be used only for the parotid glands, but later special cups for the much more responsive submaxillary glands,[2] which would not fall even when the children talked, ate, and opened their mouths widely, were also devised. These cups consist essentially of an oval-shaped inner chamber surrounded by a kidney-form vacuum chamber with wing-like sides of wide suction surface, with a notch for the tongue ligament and with a silver net to prevent injury of the mucosa through soaking. Still more recently saliometers with one external vacuum chamber and two small inner receiving chambers, separated from each other by thin vacuum layers, have been constructed to take separate records from each submaxillary gland. To fit individual ducts the saliometers are made in different sizes: the submaxillary—7–11 mms. long, 16–25 mms. wide, 1.5–2 mms. thick, with inner chambers 3–6 mms. long and 8–12 mms. wide; the parotid—7–10 mms. in diameter, 3–4 mms. in thickness, with 1.5–2 mms. of space between the outer and the inner walls of the vacuum chamber.

7. The experimenter was isolated from the subjects very early in Krasnogorski's investigations, but the early isolation by means of only a wooden screen was very crude, the food was administered directly by the experimenter, and secondary cues were thus by no means completely excluded. Krasnogorski's new laboratories, however, modeled after those of Pavlov, are extra-stimuli proof, with an inner chamber for the child, and with all stimuli delivered automatically, by pneumatic pressure or by electric current. Solid food is transmitted automatically in containers, different containers being installed for different kinds of food, while liquid food or acid is delivered by means of silver tubes placed in the interior of the mouth. The responses to both the conditioned and the conditioning stimuli are recorded kymographically, the secretory

[2] In one study the squeezing of a lemon in front of a child for 30 seconds produced in 5 trials an average of 5–6 drops from the parotid and 30.4 drops from the submaxillary glands.

response being also, as a rule, transformed into a kymographic record through closing an electric circuit and thus affording an immediate comparison between the conditionings of the motor and the glandular effectors.[3] The electric circuit is closed by letting the saliva displace either a drop of an electrolytic solution or a drop of water which falls on a sensitive lever to which a platinum wire, suspended over a mercury bath, is attached. With the exception of the recently used rather interesting but probably too complex and not very uniform stimuli of words and phrases from dictaphones, the conditioned stimuli in Krasnogorski's laboratory for children are of the same type as those in Pavlov's laboratory for dogs. They are applied, except in special cases, 5–20 seconds before the conditioning stimuli, the intervals between separate combinations being 2–10 minutes and altogether 3–10 combinations being performed daily.

8. *Kransogorski's Early Experiments.* These experiments have been summarized by Mateer (57), but in view of a number of errors in her summary as well as for some further analysis, they will be reviewed briefly again. In the first experiment (25), in 1907, the feeding response of a three-and-a-half-year-old child was apparently conditioned to the ringing of a bell, as, after a number of combinations of the bell with the food, the average[4] number of swallowings in 10 3-minute periods was 11 when food was given, 7 and 1/3 during the ringing of the bell, and 3.2 when neither stimulus was given. In the second experiment (26, 27), in 1908, the conditioning of two six-year-old children and one three-year-old child was studied from kymographic records of their swallowings and mouth openings. The three-year-old child formed a C–R to the ringing of a bell after a few dozen combinations, the C–R being retained after a recess of two weeks; the two six-year-old children formed a C–R to a tone of a tuning pipe, but the response was very generalized, although no continued effort to differentiate it by the method of contrasts, or the alternate application of the stimulus to be conditioned with and the stimulus to be differentiated without the conditioning stimulus, was made. All three

[3] The secretory C–R, while not as quickly formed, is, as a rule, more readily differentiated and negatively conditioned than the motor C–R, thus apparently confirming an early supposition by Johnson (Behav. Monog., 1913, *2*, No. 3, p. 3) in his disputing the fine pitch discriminations of dogs obtained by the Russian experimenters, that the differential threshold may be lower for the secretory than for the motor response.

[4] Unless otherwise stated, statistical measures have been computed by the reviewer.

children formed a C–R to scratching the arm, which in the six-year-old children was differentiated by the method of contrasts from similar scratching of the foot, while in the three-year-old child the response to the arm became specific without non-reinforced stimulations of the foot. The children also formed successive C–Rs to a tactile stimulus, the conditioned stimulus acting for 30 seconds and the food being given after a pause of 10 seconds. The C–R appeared on the 17th trial, at first during the action of the conditioned stimulus, but with further training, 6–10 seconds after the cessation of the conditioned stimulus. The simultaneous C–Rs became unconditioned after three non-reinforced stimulations, while the successive C–Rs were not unconditioned until after 11 non-reinforced applications of the conditioned stimulus, the intervals between non-reinforced applications being five minutes during the first five trials and ten minutes afterwards.

9. In 1913 Krasnogorski (28, 29) gave a general summary of his early experiments before the 17th International Medical Congress in London, but presented very few detailed data in support of his conclusions. He stated that children form simultaneous C–Rs after 2–10 combinations, successive C–Rs after 20–30 combinations, and negative C–Rs after 5–10 combinations; that successive C–Rs in children are quite specific, that the specificity of negative C–Rs is a function of the "type" of the child's nervous system, and that unconditioning is difficult in some neuropathic children, 31 trials being required in one case. A special form of conditioning named "loading and discharge," but which would now be more readily classified as the formation and differentiation of a C–R to a compound stimulus, is described. A five-year-old child who had a C–R to a bell was repeatedly fed only when the bell was followed, after a 3-minute interval, by a tactile stimulation; as a result the C–R appeared only in response to the combination of bell followed by tactile stimulation, but not when the bell was given alone. Another account, the disappearance of a C–R to a tactile stimulus when the bell was rung three minutes before, is apparently a case of a rather prolonged after-effect from the stimulation by the bell. The statement in one part of the summary that children begin to form simple C–Rs in the second half-year of their lives, is plainly contradicted by an assertion in another part of his summary that 5–6 month-old babies learned to differentiate between white and red lights, and 7–8 month-old babies learned to discriminate between various odors.

10. Krasnogorski's failure to present his data more adequately, the inconsistency of some of his statements and the incongruity of certain of his brain hypotheses, have been pointed out by Mateer (57), but a number of her animadversions are due either to errors of fact or to misinterpretations. Thus surprise is expressed by Mateer (87) that a child in Krasnogorski's laboratory was able to form a differential C–R to pitch when the food was given 10 minutes after the conditioned stimulus, while in point of fact the interval was only 10 seconds. Her criticisms of Krasnogorski's failure to use equal intervals (88) between separate combinations are similarly unjustified, in as much as intervals in conditioning are intentionally varied in order to preclude the formation of rhythmical time C–Rs. Neither is there anything "mystical" in Krasnogorski's use of "analyzers," which, as is well known, refer merely to parts of the cortex supposedly involved in receiving and elaborating stimuli of some particular modality. Mateer also confuses "conditioned inhibition" and Krasnogorski's "loading and discharge," unconditioned reflexes and natural conditioned reflexes, and has some minor errors with regard to the age of the subjects and the use of the apparatus.

11. *Later Experiments from Krasnogorski's Laboratories.* These experiments will be reviewed under the following headings: the formation of Differential, Successive and Negative C–Rs, and of C–Rs to Complex Stimuli; the Effect of Diet, Disease and Other Temporary Organismic Disturbances, and of Extraneous External Stimulation on the C–R; Hypnosis, Sleep, Experimental Neurosis and the C–R; C–Rs in Pathological Children; Norms of the C–R. This topical division is by no means analytical, having been made largely for rhetorical reasons. The topics are neither completely inclusive nor mutually exclusive, the inclusion of an experiment under a particular heading being based upon the major types of problems studied, without regard for other significant findings. A complete analytical division of all phases of conditioning of children is presented at the end of the review.

12. Differential C–Rs. Shastin (70) made a rather careful study of a differential tactile C–R and of the after-effects of the negative differential stimuli in a ten-year-old child, using indices of both the secretory and the motor responses. The conditioned stimulus was applied to the knee and preceded the feeding of the child with sugared beets by 30 seconds, while the average interval between successive trials was 5.35 minutes with a σ of 1.87. The

secretory C–R first appeared on the 20th trial, became stable and reached 10 drops per 30 seconds on the 30th trial, while the motor C–R was present at the 8th trial. The negative stimulation of the foot and the differentiation by the method of contrasts were begun on the 48th trial and altogether 243 positive and 110 negative stimulations were made by the experimenter.

TABLE I

FORMATION OF A TACTILE DIFFERENTIAL C–R IN A TEN-YEAR-OLD CHILD

Kind of measure		*Magnitude of C–R*				*Latency of C–R (seconds)*			
		Salivary (drops in 30 seconds)		*Motor (cms.)*		*Salivary*		*Motor*	
	Stimulus	*Positive (knee)*	*Negative (foot)*	*Positive*	*Negative*	*Positive*	*Negative*	*Positive*	*Negative*
N (Number of trials*)		23	45	21	46	23	45	21	41
Mean		9.825	5.310	1.738	1.681	3.475	5.710	1.470	1.944
Range		6–15	1–11	0.53–2.73	0.03–2.58	1–8	1–22	1.0–2.5	1–3
S.D.		2.620	2.660	0.578	0.606	1.920	3.500	0.346	0.490
V		26.67	50.09	33.26	36.05	55.25	61.30	23.53	24.68
$S.D./\sqrt{N}$		0.546	0.396	0.126	0.089	0.400	0.522	0.075	0.077
D		4.515		0.057		2.235		0.474	
S.D. (diff.)		0.676		0.155		0.657		0.107	
D/S.D. (diff.)		7.550		0.368		3.402		4.430	

* Only trials with regular intervals between them, and thus not possibly influenced by after-effects, have been used in the computation.

13. The main results of the formation of the differential C–R are presented in Table I, which has been computed by the reviewer from Shastin's data. It may be seen from this table that, although the negative stimulus always elicited some response, the difference between the responses to the negative and to the positive stimulus was fully reliable in the secretory C–R for both magnitude and latency, but only for latency in the motor C–R.

14. The greater sensitiveness of the secretory C–R is also shown in Table II, which presents the gradual development of the differentiation, after 49–59 positive and 1–6 negative applications and after 83–98 positive and 17–25 negative applications.

TABLE II

DEVELOPMENT OF A TACTILE DIFFERENTIAL C–R IN A TEN-YEAR-OLD CHILD

Kind of stimulus	*When tried*	*Average magnitude of C–R*		*Average latency of C–R (seconds)*	
		Salivary (drops)	*Motor (cms.)*	*Salivary*	*Motor*
Positive (knee)	(49–59)+ (1–6)–	8.00	2.13	3.33	1.13
Negative (foot)	(49–59)+ (1–6)–	5.17	2.28	4.83	1.02
Positive (knee)	(83–98)+ (17–25)–	11.75	2.56	3.13	1.35
Negative (foot)	(83–98)+ (17–25)–	6.44	2.10	5.44	1.62

15. After-effects were studied mainly by applying the positive stimulus five seconds after the negative, and the results, which are presented in Table III, would appear to suggest a consistent increment in the subsequent C–R, although the D/S.D. (diff.) 1.757 is not sufficiently reliable.

TABLE III

AFTER-EFFECTS OF NEGATIVE DIFFERENTIAL STIMULI

Kind of measure	*Magnitude of salivary C–R (drops in 30 seconds)*	
	Usual intervals	*Positive following negative by 5 seconds*
N	8	8
Mean	10.25	13.75
S.D.	2.47	5.05
S.D./N	0.873	1.785
D	3.50	
S.D. (diff.)	1.987	
D/S.D. (diff.)	1.757	

16. The results of another part of the experiment in which after-effects were investigated by applying the negative stimulus once, twice, or four times in succession before the positive stimulus,

with intervals of 60 seconds between the successive applications of the negative stimulus as well as between that of the negative and positive stimuli, are too few to warrant statistical computation and tabular presentation. They are an increase in 30 seconds of 3 drops by one application, of 3 by two applications, and of 6 by four applications, when tried after 99–105 positive and 26–33 negative applications. After 198–202 positive and 87–93 negative applications the results were a respective decrease of 4 and 5 after one and two applications, and an increase of 12 after four negative stimulations, while after 239–243 positive and 104–110 negative applications the respective results were a decrease of 2, 2, and 3 drops. The seemingly greater tendency for the negative stimuli to cause a decrement in the subsequent C–R, after longer training of the differential C–R, is explained by the experimenter in Pavlovian terminology as due to a change from positive to negative induction, or inhibition, but, of course, this tendency is by no means established from the meager data, nor would such an explanation be necessary if such changes did occur.

17. Successive C–Rs. An investigation of successive C–Rs in four children—one six years old, two four-and-a-half years old, and an infant five months old—was made by Leonow (53). The conditioned stimuli, which always lasted for 30 seconds, were the sounding of a metronome of 104 beats per minute and a tactile stimulation of the lower third of the thigh or the forearm for the four-and-a-half-year-old children, the lighting of a lamp of 50 c.p. for the six-year-old child, and an electric bell for the infant. The pauses between the cessation of the conditioned stimuli and the beginning of the conditioning stimuli—or feeding with chocolate the three older children and nursing the infant—varied from 5 to 60 seconds, and altogether 3–6 trials with intervals of 3–5 minutes between them were made daily. Kymographic records of mouth and throat movements were taken in only 60 percent of the trials, and only of the three older children; in the other trials the observations of the swallowing movements were made by the experimenter directly and the time recorded by means of a stop-watch, while in the infant only lip movements were observed. The C–Rs in the six-year-old and in the five-month-old children first appeared on the 18th and 20th trials and became stable on the 47th and 46th trials respectively. In the four-and-a-half-year-old children the auditory C–R first appeared on the 31st and 36th trials, becoming stable on the 61st and 63rd trials; the tactile C–R appeared on the

10th and 13th trials and became stable on the 25th and 30th trials, some positive transfer apparently taking place from the auditory to the tactile conditioning.

18. As in dogs, the most difficult and most easily disturbed part of the successive conditioning was the establishment of right pauses between the application of the conditioned stimulus and the appearance of the C–R. Thus, when one child, after 113 trials of successive conditioning, had once been given the chocolate by mistake during the action of the conditioned stimulus, the pause was disturbed and 36 more reinforced successive combinations were

TABLE IV

EFFECT OF APPLICATION OF A NEGATIVE TACTILE C–R UPON SUBSEQUENT APPLICATIONS OF A POSITIVE TACTILE C–R

Age of negative C–R (no. of trials)	*Age of positive C–R*	*Distance bet. positive and negative pts.*	*Interval tested*	*Change in positive C–R*
285–296	60–70	3 cms.	5 minutes 10 minutes 15 minutes	absent absent latency increased
313–324	49–56	6 cms.	½ minute 1 minute 3 minutes 5 minutes	absent latency increased no effect no effect
330	122	12 cms.	1 minute	no effect
331	123	24 cms.	½ minute	no effect
430–433	49–56	3 cms.	2 minutes	no effect

necessary to re-establish it. Similarly, when with the same child a recess of 18 days was taken after the 95th trial, the C–R itself was well preserved, but reinforcements were required for restoring the right pause; the pause was also easily disturbed by extra stimuli such as loud talking. The establishment of C–Rs with shorter pauses facilitated the formation of C–Rs with longer pauses.

19. Negative C–Rs. Panferov (41) studied the specificity and after-effects of negative C–Rs in a child who had a well-established positive C–R to a metronome of 104 beats per minute. A point on the left knee was stimulated tactually, the stimulation followed by the sound of the metronome, and the combination never reinforced by food, while stimulations of other points on the child's body were followed by the metronome and always reinforced. After a num-

ber of trials the negative differential C–R became established within an area of three square cms. around the point on the left knee. The after-effects of the stimulations of the negative points plus the metronome upon subsequent stimulations of the positive points plus the metronome, at various distances and after different time intervals, were then investigated and, as may be learned from Table IV, were found to be the greater the smaller the distances of the positive from the negative points, the shorter the time between their respective stimulations, and the newer the negative C–R. It may be seen, however, that in comparing the time and distance factors of the after-effects of the application of the negative tactile stimulus, the factor of the total number of positive and negative applications was not held constant, although its possible influence evidently would not account for the rather definite differences in results.

20. The after-effects of negative C–Rs were also investigated by Shastin[5] (51) in a child who had a positive C–R, formed after 2–4 combinations, to the sound of a metronome, and a negative C–R, formed after 4–5 trials to the metronome plus the lighting of a lamp. When the negative combination was applied twice in succession, 60, 30, or 15 seconds before the metronome, the salivary secretion during 30 seconds was reduced respectively from 9 to 5, 9 to 3, and 5 to 0 drops. This decrement in the subsequent C–R occurred after a total number of 95, 97, 99 positive and 6–7, 8–9, 10–11 negative applications, although after a total number of 163 positive and 26–27 negative stimulations, no after-effect was observed after an interval of 30 seconds.

21. In another experiment, Shastin (69) studied the formation, differentiation, and after-effects of negative successive C–Rs in a 7 and in an 8-year old child. In the 8-year old child the positive stimulus was a tactile stimulation, the negative stimulus the sound of a metronome, and the interval between the application of the two stimuli 30 seconds; in the 7-year old child the positive stimulus was a metronome, the negative a tactile stimulation and the interval between the two stimuli 15 seconds. The negative successive C–Rs were formed very readily after two combinations and were—after a few experimental days—as readily differentiated by the method of contrasts from a combination of the positive and the

[5] The experiments with reference number 51, as a rule lacking important relevant data, have been taken from Krasnogorski's recent summary (51). The complete reports of these experiments have either not yet been published or, in some few cases, have not yet been available to the reviewer.

negative stimuli applied simultaneously and reinforced by food. The duration and the degree of the after-effect of the negative combination upon a subsequent application of the positive stimulus was found to decrease with the age of development of the negative C–R, and to increase with the number of consecutive applications of the negative combination, as may be seen from Table V. The experimenter also formed a negative C–R in a 10-year old child to a combination of a tactile stimulation and the flashing of a lamp of 1000 c.p., and found that when this negative combination was applied simultaneously with a bell and reinforced by food, subsequent additions of the bell to the negative combination "disinhibited" the negative C–R, or caused a positive food C–R to appear.

TABLE V

AFTER EFFECTS OF NEGATIVE C–Rs UPON SUBSEQUENT POSITIVE C–Rs

Age of negative C–R	*Child I*		*Child II*	
	Interval tested	*Effect upon positive C–R*	*Interval tested*	*Effect upon positive C–R*
1	7 minutes	disappeared		
2	2 minutes	latency increased	1 minute 30 seconds	latency increased disappeared
3	1 minute	latency increased		
4			30 seconds	latency increased
5	30 seconds	latency increased		
6			30 seconds	latency increased
6 & 7	7 minutes 30 seconds	latency increased disappeared		
7 & 8	7 minutes	latency increased	3 minutes 30 seconds	latency increased disappeared
9			15 seconds	no effect

22. A negative C–R to a bell plus a lamp was also formed in Krasnogorski's laboratory (45) in an eleven-year-old child who had a natural right parotid fistula. The average secretion per 30-second period was one cc.[6] during the action of the negative com-

[6] The average conditioning secretion from the fistula in sixteen 5-minute periods, during which the child chewed 20 gms. each of beets, carrots, lemons or apples, was 8.538 ccs. The average secretion at the same time from the normal left parotid, measured by means of the saliometer, was 9.08 ccs., which, however,

bination and 3.99 ccs. during the application of the lamp alone, the averages having been computed respectively from 4 and 11 trials. The positive C–R became unconditioned after 5 non-reinforced applications at intervals of 2 minutes, the drops of saliva in successive 30-second periods being: 15,8,5,3,3,0, with respective latencies of 4,6,7,17, and 8 seconds.

23. C–Rs to Complex Stimuli. Under this heading are included C–Rs to chains—or successive series—of different stimuli of the same or of different modalities, each stimulus following the other at regular intervals and the last being reinforced by food; C–Rs to chains of stimuli, each stimulus following the other at regular intervals and each being reinforced; C–Rs to spoken phrases. Some of these recent experiments are only briefly summarized, as their complete reports have not yet been available to the reviewer.

24. Derevichkova (51) formed a C–R in an eight-year-old child to a chain of four stimuli: red lamp, whistle, rhythmical pressure, white lamp—the stimuli following each other at regular intervals of five minutes and each stimulus being reinforced by food. When the order of presenting the stimuli was reversed once, the conditioned secretion in 30 seconds became reduced from 25 to 11 drops for all four stimuli and from 4–6 to 1–4 drops for individual stimuli. Still, after some reinforcements, the C–Rs to the reversed order increased, reaching a total of 27 drops with 5–6 drops for the single stimuli, while the C–R to the original order diminished to a total of 16 and 1–5 drops for individual stimuli, the number of drops referring to the secretions during 30-second periods. When again the second stimulus of the chain, the rhythmical pressure, became unconditioned by non-reinforcement, and the stimuli were presented by interchanging the places of the second and the fourth stimulus in the chain, the C–R to the former stimulus reappeared and that to the latter diminished. Additional training, however, with reinforcement of the fourth and non-reinforcement of the second stimulus undid this effect of the order of presentation, restoring the C–R to the positive fourth stimulus and causing its disappearance to the negative second stimulus.

25. Panferov (51) established a C–R to a chain of stimuli: metronome, red lamp, bell, tactile, blue lamp, bubbling of water, white lamp, vibration of telephone diaphragm—each stimulus last-

did not test the reliability of the apparatus, for although the food was alternately chewed on each side, the responsiveness of the two glands was not equated.

ing for 30 seconds and the last being reinforced by food. The magnitude of the C–R to each stimulus seemed to depend not only upon the nature and intensity of the stimulus, but also upon its closeness to the administration of food. Furthermore, when one visual stimulus of the chain immediately preceded the feeding, the C–Rs to the other visual stimuli in the chain likewise became increased. Panferov also found that when a metronome, S_1, was associated a few times with a lamp, S_2, the lamp similarly associated with a tactile stimulus, S_3, the tactile stimulus with a visual stimulus of exposing a circle, S_4, and then a C–R was formed to the metronome, S_1—S_2, S_3, and S_4 likewise produced the C–R, although similar control stimuli not similarly associated elicited no response.

26. Wolowick (84) established a C–R in an 11-year-old child to a chain of three auditory stimuli: bubbling of water, metronome of 120 beats per minute, bell; and of three visual stimuli: red, green, and blue lamps—each stimulus lasting for 10 seconds and the last stimulus of each chain being reinforced by food. The motor C–R to the auditory chain appeared on the first trial, but, for 8 subsequent trials, only after the application of the third stimulus, the bell; the order of presentation was then reversed so that the bell was the first stimulus, and the C–R appeared for 22 trials after the application of the first stimulus, even when the original order was later restored. The secretory C–R to the auditory chain first appeared on the 5th trial, but reached a magnitude of 5–7 drops in 30 seconds only on the 31st trial; when the order was reversed, secretion decreased to an average of 4.733 drops for 11 trials.

27. The C–R to the visual chain appeared on the second trial, its magnitude being, however, as a rule smaller than that of the auditory chain. When in one trial the middle stimulus, and in another trial, the last two stimuli of the visual chain had been left out and replaced by the remaining stimuli, the C–R decreased respectively from 5 to 2 drops, and from 4 to one drop, while immediate subsequent application of the complete chain resulted in an increased C–R of 11 and 9 drops respectively. When a negative C–R of pressure plus the green lamp was formed and applied three consecutive times immediately before the visual chain, the C–R to the latter disappeared, although no subsequent effect upon the auditory C–R was observed. However, the auditory C–R did decrease from 8 to 4 drops when it was given simultaneously with the negative combination. When, finally, the auditory and visual chains were applied alternately on the same day, the magnitude of the

ERRATA.

Page 23, 6th line from top. Delete present line, which is duplicate of line 12, and read instead:

after 162 trials 3 drops in 30 seconds and the latter giving no re-

auditory C–Rs was larger in 70 percent of the trials, the visual in 15 percent, while in 7 percent of the trials the C–Rs were equal, and in 8 percent of the cases completely failed to appear.

28. Shastin (51) differentiated the sentence: "A red light is burning" from "No red light is burning", the former producing
after 162 trials 3 drops in 30 seconds & the latter giving
~~ment of Shastin (68) in which two 6-year-old children and one~~
sponse after 60 non-reinforced trials. The child also had a C–R of 4 drops per 30 seconds to the lighting of a red lamp; this positive C–R, however, was little affected by uttering at the same time the negative sentence: "No red light is burning".

29. A case of C–Rs to complex stimuli is also an early experiment of Shastin (68) in which two 6-year-old children and one 4-year-old child had been blindfolded 15 seconds before the application of conditioned auditory and tactile stimuli. When these stimuli were, however, tried alone, without blindfolding, the C–Rs did not appear until after one and eight reinforcements respectively and did not reach their normal latencies until after nine and fourteen reinforcements. Similarly in the 4-year-old child, who had a C–R of 556 combinations to a metronome preceded by blindfolding, the response to the metronome alone was not elicited even after seven reinforcements; nor was there any C–R to the blindfolding alone, tried in the 4-year-old child.

30. The Effect of Diet. The effect of different diets upon conditioned as well as upon conditioning salivation in a 10-year-old child was studied by Wolowick (83). Four diets, each lasting for 6 weeks, were used: a mixed diet—280 gms. of carbohydrates, 50 of proteins, 42 of fats, with a total calorie value of 1770; a carbohydrate diet—420 gms. of carbohydrates, 30 of proteins, 30 of fats, with a total calorie value of 2120; a fat diet—200 gms. of fats, 50 of carbohydrates, 40 of proteins, with a total of 1905 calories; a protein diet—200 gms. of carbohydrates, 90 of proteins, 30 of fats, with a total calorie value of 1560. Conditioning salivation was tested from time to time by the quantity of saliva produced in 3-minute periods of consuming at 10-minute intervals 20 gms. of beets, 10 of bread and pastry, and 30 cc. of lemon juice; while conditioned salivation was compared by the number of drops of saliva in 30-second periods to 5 well-established conditioned stimuli: a tactile stimulation, a metronome, two electric bells of different intensities, and the flash of an electric lamp. The results are presented in Table VI, from which it may be seen that the order of effectiveness of the particular diets for both conditioning and con-

ditioned salivation was carbohydrate, mixed, fat, and protein. The presented data do not, however, permit statistical evaluation of the reliability of the differences between the averages. It is also to be regretted that the calorie values of the diets, which may have been factors in the differences between the results, were not equated by the experimenter.

TABLE VI

EFFECT OF DIFFERENT DIETS UPON CONDITIONED AND CONDITIONING SALIVATION IN A 10-YEAR-OLD CHILD

Kind of diet	*Conditioning salivation (average cc. in 3 minute periods)*			*Conditioned salivation (drops in 30-second periods to 5 conditioned stimuli)*					
	Food tested			*Percentage distribution*					*Average*
	Beets	*Bread and pastry*	*Lemon juice*	*0–10 drops*	*10–20 drops*	*20–30 drops*	*30–40 drops*	*40–45 drops*	
Carbohydrate ...	9.2	6.75	3.6	8	24	28	32	8	27
Fat	7.6	5.05	3.2	18	37	36	9	0	19
Protein ...	7.0	4.20	3.1	24	50	26	0	0	16
Mixed ...	8.0	5.00	3.2	20	13	41	33	13	20

31. Juschtschenko (32) studied the effect of a homogeneous diet, sugared rice, upon a successive motor C–R—sounding a metronome for 30 seconds with a pause of 15 seconds—in a 7-year old child. The response, which ranged from 3.2 to 3.5 and averaged 3.24 cms. on the day before the homogeneous dieting, fell on the first day of dieting to 2.0–2.3 cms. and on the second to 1.9–2.3 cms., with respective averages of 2.32 and 2.1—all measurements having been computed from five trials. When the homogeneous dieting was broken for 12 days, during which the child was given mixed food, the C–R rose again to 2.5–2.6 cms. The dieting was then begun anew and the C–R dropped again to 0.37–2.5 on the second and to 0.44–2.1 cms. on the third day of dieting (the results of the first day are not included, as the C–R was tried during lunch instead of during the usual morning hours). When the child now received white bread of the same composition and calorie value as the rice, the C–R went up once more to 1.0–2.5, with an average of 1.92 cms. for five trials as compared with an average of 1.5 cms. for 13 trials in the two preceding days of homogeneous dieting.

Similar results are reported on a 7-year-old child fed on Edam cheese and on another child fed on cocoanut butter, but the data on these children are even more meager and the differences smaller than in the experiment with sugared rice. The experimenter's general conclusion that the effect of a homogeneous diet on the C–R is felt in 24 hours and becomes very distinct after two days is thus, perhaps, no more than suggestive and is doubtless in need of confirmation.

32. A more extensive experiment on the effect of a homogeneous cheese diet upon conditioned and conditioning responses of an 11-year-old child was performed by Machtinger (51). The following responses were tested: a C–R to a bell with cheese as the conditioning stimulus, a C–R to a metronome with cranberries as the conditioning stimulus, the natural C–R to the sight of cheese, and the conditioning response to eating cheese. The results are presented in Table VII. In this table the magnitudes of the secretory C–Rs are given in drops per 30 seconds for the laboratory C–Rs,[7] in drops per three minutes for the natural C–R, and in ccs. per three minutes for the conditioning salivation of eating. The magnitudes of the laboratory motor C–Rs are given in cms., while latencies are given in seconds; two entries in the same column indicate the results of two separate trials.

33. As seen from this table, three days of homogeneous cheese dieting only increased the C–R to its conditioned stimulus, the bell, but further dieting definitely decreased both the conditioned and conditioning salivation to cheese, the former altogether disappearing after 40–65 days and the latter being decreased finally to nearly one-fourth of its original amount. The motor C–R to the bell was less affected, showing a decrement after only 40 days and disappearing after 65 days of dieting, while the C–R to the metronome with cranberries as the conditioning stimulus was apparently little affected by the cheese dieting.

34. The Effect of Disease. Scarlet fever, measles, typhoid fever, and mumps are all reported (51) to have diminished the C–R. In one case of scarlet fever in an 8-year-old child the natural C–R to the sight of food reached its normal magnitude only after 35 days from the inception of the disease. In a case of mumps the C–Rs to a metronome, to a lamp, and to a tactile stimu-

[7] All C–Rs in the review are laboratory, the term "laboratory" being used here merely in contradistinction to "natural" C–Rs which the organism assumedly acquires in its life course.

TABLE VII

Effect of Homogeneous Cheese Dieting upon Conditioned and Conditioning Responses in an Eleven-Year-Old Child

Time of experimentation	*Amount of cheese consumed*	*C–R to bell with cheese as conditioning stimulus*				*C–R to metronome with cranberries as conditioning stimulus*				*Natural salivary C–R to sight of cheese*	*Salivation while eating cheese (in ccs.)*
		Magnitude of salivary C–R	*Latency of salivary C–R*	*Magnitude of motor C–R*	*Latency of motor C–R*	*Magnitude of salivary C–R*	*Latency of salivary C–R*	*Magnitude of motor C–R*	*Latency of motor C–R*		
Before diet ...		9	6	1.9	1.0	8	6	2.4	1.3	15	6.2
3 days after diet	0.8 kgs.	12	2	2.2	0.3	7	7	2.0	1.0		
21 " "	4.4 "	5	2	1.9	0.9	7	11	2.0	1.4		
30 " "	6.0–6.6 " (estimated)									1	3.7
37 " "	7.8 kgs.	1	12	2.3	1.0	9, 10	2, 5	1.2, 1.6	1.0, 1.5		
40 " "	8.8 "	0	0	1.3, 1.6	1.0, 6.0	13, 14	11, 13	1.2, 1.4	2.0, 10.0		
65 " "	15.0 "	2	10	0	0	13	3	1.8	0.9	0	1.7

lation completely disappeared in the first week, and reached their normal magnitudes only on the 26th day of the disease.

35. Other Temporary Organismic Disturbances. Juschtchenko (51) noted a decrement in a C–R from four drops to one drop in 30 seconds, when a child wished to urinate, the response having been already reduced to 2 drops six minutes before the complaint. Prevented from voiding urine for eight and fourteen minutes, the child cried and the C–R disappeared on the first trial, while immediately after urination the C–R reappeared and went up to 2 drops in 30 seconds. In another child a C–R of 21 drops in four 30-second periods to a chain of four stimuli decreased to 3 drops two hours after the child's boxing, while in a third child a C–R of 21 drops in three 30-second periods to a chain of three stimuli diminished to 3 drops after attendance at a theatre play. In a fourth child conditioned salivation was reduced for a few weeks when the child was told of the death of his father.

36. Effect of Extraneous External Stimulation. Juschtchenko (33) studied rather extensively the disturbing effect of extraneous external stimuli upon the motor and secretory C–Rs in six children ranging in age from four to thirteen years. All children had a C–R to a metronome of 100 beats per minute, sounded for 30 seconds before the administration of food. Four of the six C–Rs were already well-established before the beginning of this distraction experiment, having been combined with food for respectively 1250, 274, 243, and 193 times; in the remaining two children the C–Rs were combined only five and ten times, eliciting the motor, but not yet the secretory, response. The following extraneous stimuli were used as distractors: auditory—bubbling of water, electric rattle, siren, whistle, a toy pistol; visual—sight of a guinea-pig, lighting of a lamp of 120 c.p.; olfactory—the odors of balsam of Peru and chloroform; tactile—stimulation of the arm; algeic—electric shock. The distracting stimuli—each stimulus applied not more than once to each child—were given five seconds before the conditioned stimulus, terminating simultaneously with the latter; the electric shock, however, was given for only eleven seconds—five before and six during the action of the conditioned stimulus. The regular training of the C–Rs was conducted with each child every day or every other day, but the experiments with the distracting stimuli were performed only once in 3–20 days.

37. The results are presented in Table VIII, which is an abridgement of the experimenter's six tables. The first three

EFFECT OF EXTRANEOUS EXTERNAL STIMULI UPON MOTOR AND SECRETORY C–RS IN SIX CHILDREN

Name of child	*Age*	*Extraneous stimulus*	*C–R in trial preceding distraction*				*C–R during distraction*				*C–R in trial following distraction*				*Time intervals*
			Magnitude of salivary C–R	*Latency of salivary C–R*	*Magnitude of motor C–R*	*Latency of motor C–R*	*Magnitude of salivary C–R*	*Latency of salivary C–R*	*Magnitude of motor C–R*	*Latency of motor C–R*	*Magnitude of salivary C–R*	*Latency of salivary C–R*	*Magnitude of motor C–R*	*Latency of motor C–R*	
A. S.	8 years	Bubbling of water	5	2	3.2	0.7	5	2	3.2	0.7	5	2	2.7	1.0	7, 8
A. S.	8 "	Electric rattle	5	2	3.0	0.6	1	29	2.8	0.7	–*	–	3.6	0.7	8, 9
A. E.	13 "	"	4	3	3.6	0.6	–	–	3.7	1.0	4	4	3.3	0.8	8, 12
B. K.	4 "	"	6	3	3.6	0.9	1	21	3.7	1.2	9	3	3.4	0.8	6, 5
A. G.	7 "	"	–	–	2.4	0.6	–	–	2.7	2.6	–	–	2.9	0.4	5, 7
A. S.	8 "	Siren	4	4	2.8	0.4	1	25	3.2	5.0	5	3	2.5	0.4	8, 8
I. O.	15 "	"	4	4	2.8	0.4	1	25	1.9	5.3	4	5	2.5	0.3	6, 9
B. K.	4 "	"	8	4	3.1	1.0	–	–	–	–	1	21	1.6	1.0	6, 1
A. G.	7 "	"	–	–	1.5	0.5	–	–	–	–	–	–	2.1	1.1	8, 3
M. A.	13 "	"	–	–	1.8	0.5	–	–	–	–	–	–	2.1	1.1	8, 3
A. S.	8 "	Electric shock	6	2	3.1	0.9	2	23	1.9	9.6	7	4	2.3	0.9	9, 8
I. O.	15 "	"	3	7	3.2	0.5	–	–	2.4	5.4	4	5	3.2	1.0	14, 14
A. E.	13 "	"	3	5	4.1	0.7	–	–	2.0	11.8	1	18	3.6	0.8	8, 8
A. S.	8 "	Guinea-pig	6	2	2.3	0.5	6	3	2.6	0.5	2	5	2.0	0.6	7, 7
I. O.	15 "	"	5	4	3.5	0.8	–	–	3.5	0.7	2	6	3.5	0.7	12, 12

* Dash indicates failure.

TABLE VIII—*Continued*

Name of child	*Age*	*Extraneous stimulus*	*C–R in trial preceding distraction*: *Magnitude of salivary C–R*	*Latency of salivary C–R*	*Magnitude of motor C–R*	*Latency of motor C–R*	*C–R during distravction*: *Magnitude of salivary C–R*	*Latency of salivary C–R*	*Magnitude of motor C–R*	*Latency of motor C–R*	*C–R in trial following distraction*: *Magnitude of salivary C–R*	*Latency of salivary C–R*	*Magnitude of motor C–R*	*Latency of motor C–R*	*Time intervals*
A. E.	13 years	Guinea-pig	6	3	2.7	0.8	1	18	2.0	1.2	3	9	1.8	0.8	6, 8
A. G.	7 "	"	–	–	1.4	0.6	–	–	1.1	19.0	–	–	1.8	1.0	6, 7
A. S.	8 "	Balsam of Peru	7	2	1.4	0.5	2	12	1.4	0.5	1	7	1.8	0.5	7, 7
I. O.	15 "	"	3	7	2.2	0.7	2	6	1.8	0.6	4	4	1.8	0.6	12, 12
A. G.	7 "	"	–	–	2.1	0.5	–	–	1.2	0.9	–	–	1.2	0.5	5, 6
I. O.	15 "	Whistle	2	13	1.9	0.4	–	–	1.9	0.7	2	4	2.0	0.5	8, 9
I. O.	15 "	Lamp	3	4	4.8	0.4	2	11	4.4	0.4	2	7	4.7	0.3	8, 7
B. K.	4 "	"	7	9	2.5	0.7	3	8	2.3	1.0	7	2	2.2	0.7	5, 5
A. G.	7 "	"	–	–	1.3	0.6	–	–	2.1	1.0	–	–	2.3	0.8	9, 6
M. A.	13 "	"	–	–	4.1	0.4	–	–	4.7	0.6	–	–	2.0	0.4	6, 5
I. O.	15 "	Toy pistol	3	4	5.0	0.4	3	6	4.3	0.3	4	5	3.9	0.3	17, 8
I. O.	15 "	Tactile	3	3	1.9	0.4	–	–	1.4	0.4	3	4	1.8	0.4	10, 10
A. E.	13 "	"	5	5	2.8	1.0	–	–	3.5	1.0	6	3	2.8	1.0	11, 9
B. K.	4 "	"	4	5	3.8	1.2	–	–	3.5	1.0	3	11	4.2	0.7	5, 5
A. G.	7 "	"	–	–	1.6	0.7	–	–	2.1	1.3	–	–	1.6	0.5	5, 3
I. O.	15 "	Chloroform	5	3	2.9	0.4	–	–	2.7	0.4	4	5	3.4	0.4	13, 12

columns in this table are self-explanatory. The next 16 columns show respectively the magnitude of the parotid secretory C–R in drops per 30 seconds, the latency of the secretory C–R in seconds, the magnitude of the motor C–R in cms., and the latency of the motor C–R in seconds in the trials immediately before, during, and after the action of the extraneous distracting stimulus. The last column gives respectively the time intervals in minutes between the three trials.

38. As seen from this table, the distractibility of the secretory C–R was much greater than that of the motor C–R, thus corroborating other results on the greater lability of the former. In the four children, who had both secretory and motor C–Rs, 18 of the 23 distracting stimuli reduced the secretory C–R and lengthened its latency, while the motor C–R was affected[8] in only four of the cases. Similarly, in the trials following those of the application of the distractions, the motor C–R decreased only twice, as compared with five decrements in the conditioned secretion. The results on both individual differences in distractibility and relative effectiveness of various distracting stimuli cannot be well evaluated by the reviewer because of the meagerness of the data, since not all stimuli were applied to each child, nor were the total numbers of applications of each stimulus equal to each other.

39. Burkowa (51) found that negative C–Rs may be formed by applying extraneous external stimuli, or even conditioned stimuli, a number of times after the beginning of the action of the conditioning stimulus—the food. One 11-year-old child, who had a C–R of 14 drops per 30 seconds to a metronome, formed a negative C–R to an extraneous stimulus of a whistle plus a metronome, when the whistle was given for 30 trials three seconds after the feeding of the child. In another child a positive C–R of 8 drops per 30 seconds to a combination of a white lamp and a metronome became negative when the lamp was similarly applied for 30 trials after the beginning of the feeding.

40. Hypnosis. The effect of hypnosis upon conditioning and upon laboratory and natural conditioned salivation was investigated by Nevsky and Levin (59) in a 9-year-old child. Conditioning salivation while eating, laboratory conditioned salivation to a bell and to a chain of three visual stimuli, and natural verbal con-

[8] A C–R is considered "affected" when the change in its magnitude or latency, or both, is greater than its normal S.D.; the S.D.s are given in Table XII.

ditioned salivation to positive suggestion of food were all studied in both hypnotic and normal states of the child. In addition, the effectiveness of degrees of positive suggestion of food and of contrary suggestion—telling the child that he does nothing when he eats, or that he eats beets when he eats cheese—were investigated in the hypnotic state. The results, although meager, particularly on laboratory conditioning, show interesting relations between the visceral-secretory and the verbal mechanisms, and are presented in Table IX. In this table the average magnitudes of the salivary laboratory C–Rs are given in drops per 30 seconds and the average latencies in seconds, while the averages of the other salivations are

TABLE IX

Salivary Secretions of a Nine-Year-Old Child to Conditioned and Conditioning Stimuli in Hypnotic and Normal States

Nature of stimulus	*State*			
	Hypnotic		*Normal*	
Food in mouth				
10 gms. cheese	2.55(10)		2.48 (5)	
10 " beets	4.84 (5)		4.74 (5)	
10 " chocolate	3.04 (5)		2.76 (5)	
10 " pastry	4.50 (5)		4.68 (5)	
Average food in mouth	3.73(25)		3.60(20)	
Positive suggestion of food				
(You are eating, chewing, etc.)				
Pastry	6.83 (6)		1.17 (6)	
Beets	5.33 (9)		2.11 (9)	
Chocolate	2.63(19)		0.67 (3)	
Degree of positive suggestion				
(You are eating, chewing, etc.)				
Ordinary beets	2.67 (3)		......	
Sour beets	4.00 (2)		......	
Very sour beets	7.00 (4)		......	
Contrary suggestion				
Child eats beets and is told that he eats nothing	4.86 (5)		......	
Child eats cheese and is told that he eats beets	2.62 (5)		......	
	Magnitude	*Latency*	*Magnitude*	*Latency*
Laboratory conditioned stimuli				
Bell	3.67(6)	5.5 (6)	2.5(2)	3.5(2)
Green + Blue + Red lamp	1.00(1)	5.4 (1)	2.5(2)	8.0(2)
Suggestion of bell	3.00(1)	7.00(1)	......	......

expressed in ccs. per minute; the figures in parentheses denote the number of trials from which the averages have been computed.

41. As seen from this table, salivation to other than verbal stimuli was apparently unaffected by hypnosis, but suggestion, or assumedly natural verbal conditioned stimuli, which produced only a fraction of the conditioning salivation in the normal state, elicited a full conditioning response in the hypnotic state, the magnitude of the response varying directly with the degree of suggestion. Suggestion, even in the hypnotic state, was, however, powerless when it conflicted with conditioning stimuli, the amount of salivation while eating beets or cheese being unaffected by the contrary suggestion.

42. Sleep. The production of experimental sleep in a child who had a positive C–R to a tactile stimulus and a negative C–R to a metronome plus the tactile stimulus by the summation of the negative stimuli was studied by Krasnogorski and Lisunova (42). The negative C–R, applied once, had no after-effect upon an application of the positive C–R one and a half minutes later, but increased the latencies of the subsequent C–Rs from 0.5 to 2.0, 3.5 and 9 seconds when the negative C–R was given consecutively at intervals of one and a half minutes, two, four and eight times; while 12 similar consecutive applications—and the child fell asleep. The ages of the negative C–Rs at these test-experiments were respectively 15, 16–17, 18–21, 46–53, and 54–65 trials with respective ages for the positive C–Rs of 275, 279, 284, 302, and 307 trials.

43. In another child, who had a positive C–R to a metronome and a negative C–R to a tactile stimulus plus the metronome, and to a patch of light plus the metronome, the number of summations of the negative stimuli required to produce experimental sleep were found by Shastin and Krasnogorski (42) to be dependent upon the time of the day as well as upon the total amount of general activity, or stimulation of the child on the experimental day. Thus, when the child was tested 9.21–9.56 A. M., 3.51–4.04, and 8.14–8.47 P. M., the number of consecutive applications at intervals of one and a half minutes of the negative combination of tactile stimulus plus metronome, before the onset of drowsiness, were respectively 12, 6, and 3; the respective ages of the negative and positive C–Rs being 46–57, 10–15, 34–36, and 156, 150, 155. Similarly, the child fell into a deep sleep on another day at 8.0–8.10 P. M. when the negative combination of light plus metronome was given for 4 consecutive trials, the age of the negative C–R being 7–10 and that of the

positive C–R 166 trials. Further, when the child was blindfolded for 13 hours, sleep did not come before 14 summations at 7.56–8.21 P. M., while when the child was both blindfolded and kept away from auditory stimuli for 13 hours, even 20 consecutive trials only lengthened the latencies of the subsequent positive C–R from 1.3 to 2.0 seconds, the respective ages of the negative and positive C–Rs being 15–28, 30–49, and 167, 168 trials.[9]

44. Experimental Neurosis. Panferov (43) produced a temporary disturbance, or a so-called "experimental neurosis," in a normal 6-year-old child by attempting to develop a differential C–R to two very close stimuli. The child who had a positive motor C–R to a metronome of 144 beats per minute, was trained to form differential C–Rs to metronomes of other rates of beating by the method of contrasts, applying the negative 1–2 and the positive stimulus 3–6 times a day. The first two differential C–Rs to metronomes of 92 and 108 beats were established rather readily by applying the negative stimuli respectively for 11 and 6 trials, after respective totals of 161 and 268 applications of the positive stimulus. Similarly, the third differential C–R to a metronome of 120 beats per minute became established after four applications of the negative stimulus and after a total of 322 positive stimulations, although in this case the latencies of the positive C–R lengthened from 0.4–0.5 to 0.8–1.9 seconds, and the general behavior of the child is given as "taciturn," "refuses to go to the laboratory," "walks and mounts apparatus slowly." Finally, after a total of 324 trials with the positive metronome, a negative metronome of 132 beats was introduced and alternate applications of the positive and negative stimuli were begun. Now, however, no trace of differentiation could be observed—both stimuli eliciting positive C–Rs of long latencies—the old differential C–R to 120 beats per minute was lost, while the general behavior of the child is described as: "rude, fights, disobedient, excited, yawns, closes eyes, falls asleep." Similar results are said to have been obtained by Siriatsky (43) in an attempt to have a child differentiate between two close tactile stimuli.

45. A temporary disturbance in the general behavior and the C–Rs of a 6-year-old child was also produced by Halutina-Zinser-

[9] Attempts to form salivary C–Rs in sleep by introducing through a tube, kept in the child's mouth during sleep, 30 ccs. of 0.5% citric acid proved unsuccessful, while even the conditioning secretion was reduced from 2.9 to 2 ccs. in natural and from 5.4 to 3.8 ccs. in experimental sleep. (51)

ling (43) through delaying the administration of food, the conditioning stimulus, longer than usual. When the child, who had a stable C–R to a metronome with a 5-second delay, was fed 30 seconds after the beginning of the application of the conditioned stimulus, the C–R became extremely unstable and the child began to yawn and grow drowsy. The 5-second delay was then tried again, but the response had already been quite deranged and disappeared for five days, regaining its normal strength only on the eighth experimental day. Now, a C–R was successfully formed even with a delay of 30 seconds after a new series of 22 trials. However, when, finally, a delay of 60 seconds was tried, the C–R again disappeared, and the child refused to go to the laboratory or fell asleep, and only a complete rest of a week enabled later the establishment of a C–R with the long delay.

46. A neurotic symptomatology has been attached by Krasnogorski (51), following Pavlov, to unusual deflections of the magnitudes of the secretory C–R, which supposedly correspond to particular neural, or behavioral, states of the children. In addition to a normal, or optimal, neural state when the magnitude of a C–R is determined by the usual potency of each stimulus, the following "abnormal" states are said to occur: an excitatory state when all C–Rs are greatly increased but their relative magnitudes are normal; an inhibitory or decremental state when the relative magnitudes of the C–Rs are normal but greatly decreased; a levelling excitatory state when the C–Rs are both increased and equal to each other; a levelling inhibitory or decremental state when all C–Rs are equal and decreased; a paradoxical state when the relative magnitudes of the C–Rs are reversed; an ultraparadoxical state when negative C–Rs become positive and *vice versa*.

47. This classification is almost entirely based on an experiment by Wolowick (82) upon a paralytic 10-year-old child with an I.Q. of 80 who had C–Rs to five different stimuli. An examination, however, of Wolowick's data, presented in Table X, shows that, not only are the data too meager, but that they do not offer in themselves conclusive evidence for the suggested symptomatology and its classification. The table indicates a unimodal distribution of the C–R magnitudes to the five different stimuli and no reliable differences between their respective averages, while the alleged specific "abnormal" phases are by no means definite, even granting the experimenter that it has been otherwise established in the laboratory that the results of experimental days A and F are nor-

TABLE X

MAGNITUDES OF SALIVARY C–RS IN DROPS PER 30 SECONDS TO FIVE DIFFERENT STIMULI ON DIFFERENT EXPERIMENTAL DAYS IN A 10-YEAR-OLD CHILD

Experimental day	*Stimuli*				
	Tactile	*Metronome*	*Lamp*	*Loud bell*	*Weak bell*
A	9(43)	12(188)	10(25)	25(41)	7(20)
B	10(46)	7(191)	10(28)	7(44)	7(23)
C	2(58)	2(208)	1(39)	2(54)	2(38)
D	4(64)	4(210)	3(46)	3(61)	6(45)
E	3(72)	9(217)	5(54)	1(68)	5(53)
F	4(73)	7(218)	5(55)	9(69)	8(54)
G	9(75)	4(220)	5(56)	3(71)	10(56)
H	0(76)	1(221)	1(57)	0(72)	0(57)
I	1(84)	3(229)	2(65)	4(80)	3(65)
Average magtude	4.67	5.44	4.67	6.0	5.33
S.D.	3.53	3.37	3.23	8.76	2.92
S.D./$\sqrt{N-3}$	1.44	1.985	1.32	3.57	1.19

(Order of presenting the stimuli always the same; numbers in parentheses indicate trial number of particular C–R.)

mal. The relative magnitudes on day G are complete reversals of those of A, those for day C are all reduced yet not relatively changed, those of I are reduced and equal to each other; but it would still be hard to definitely classify the results of the other days in which the reversal, the decrement, or the increment of the C–R occurred in response to only some, but not to other, of the stimuli.

48. C–Rs in Pathological Children. Cretinism. An interesting, rather extensive experiment on various phases of conditioning in a 15-year-old cretin, before and after a regular administration of dessicated thyroid, was performed by Shastin (71, 72). The child began to walk at one and a half years, to talk in monosyllables at five years; before thyroidization his height was 95 cms., weight 18 kgms., ossification by roentgenogram—two years, and he could count only to three. A C–R to a tactile stimulus in the region of the right knee was formed with difficulty: the motor response first appeared on the 69th trial, then disappeared and

reappeared on the 89th trial; while the secretory response first appeared on the 104th trial. The magnitudes of the two responses were low: 2–3 drops of saliva in 30 seconds and about one cm. displacement on the kymograph. The motor C–R was further characterized by long latencies—2–6 seconds—and by slower rate of reaction—9 seconds before mouth was open to its maximum—although after five months of experimentation the latencies became 1.3–1.5, and the rate of reaction decreased to 4.5 seconds. An attempt, after 119 trials, to establish a negative C–R to a metronome plus the tactile stimulus was unsuccessful, even though the metronome plus the tactile stimulus was applied without reinforcement 26 times and the tactile stimulus alone reinforced for 55 additional trials. Furthermore, when the metronome was tried alone it elicited a positive C–R of the second order of 2 drops of saliva in 30 seconds, accompanied by a motor response of .7 cms.[10] Two more attempts to form negative C–Rs in the child to a bell plus the tactile and to a light plus the tactile stimuli similarly failed, positive C–Rs of the second order again being formed. Experimental unconditioning of the C–R in the child was apparently rather slow, the tactile stimuli requiring 7 consecutive non-reinforced applications for the disappearance of the secretory and 8 for the disappearance of the motor response, while the C–R of the second order to the bell disappeared first after 8 non-reinforced applications, reappeared the next day and was still present after a total of 25 non-reinforced applications.

49. Differentiation was investigated by training the cretin to differentiate by the method of contrasts between the tactile stimulus applied to the knee and to the foot 18 cms. away. The differential C–R was apparently partly formed after 9 consecutive non-reinforced stimulations of the foot, as on the 10th trial the motor C–R was absent and the secretion was only one drop with a latency of 25 seconds, compared with 4 drops, a latency of 6 seconds, and a motor C–R of .8 cms. to the preceding 256th stimulation of the knee. However, unlike in normal children, no bilateral transfer of the differentiation was observed, the differentiation being lost when the left knee and foot were tested. The process of differentiation was further investigated by attempting to develop a differential

[10] This formation of C–Rs of the second order, instead of negative C–Rs has been also observed in idiots by Panferov (51), who is further reported to have found that a C–R first appearing in an idiot on the 6th trial could not later be experimentally unconditioned for two years.

C–R between the stimulation of the foot and three other parts—6, 12, and 24 cms. away—to which positive C–Rs had previously been formed, but while the differentiation from the point 24 cms. away was effected, the attempts at finer differentiation resulted in a "neurosis" with a consequent loss of the older differential C–Rs.

50. When now, after five months of conditioning experimentation, thyroidization with daily doses of 0.2–0.6 gms. of dessicated thyroid was begun and continued for a year, the child's height reached 109 cms., his weight—22 kgms., ossification—nine years, with a reported corresponding growth in intelligence, and an increase of conditioning salivation from 5.85 to 9.575 ccs. from both parotid glands in three minutes while eating. The following changes in the cretin's C–Rs were then observed. The secretory C–R increased to 7 drops in 30 seconds, the latency of the motor C–R became normal, dropping to 0.9 seconds, the rate of reaction decreased from 4.5 to 0.7 seconds, but the magnitude of the motor C–R remained unaffected and still below normal. The experimenter's conclusion that the after-effects of negative stimulation became shortened after thyroidization is, however, hardly warranted by the scanty data.

51. Other Physical and Mental Disorders. The formation in a 10-year-old child, suffering from infantile paralysis and having an M.A. of 8 years, of 5 simple positive C–Rs to a metronome of 120 beats per minute, an electric lamp of 25 c.p., 2 bells of different intensities, and to a tactile stimulation as well as the formation of a complex C–R to a chain of 3 stimuli—bell, lamp, and tactile stimulation—was studied by Wolowick (82). The first motor C–R to the metronome appeared after 42 combinations and the secretory C–R after 97 combinations reaching a magnitude of 6–12 drops per 30 seconds; the subsequent C–Rs—both motor and secretory—were, however, formed very readily after 1–3 trials. The C–R to the chain of stimuli was also formed easily, its magnitude being at first smaller but later greater than those of the C–Rs to the individual components. A comparison between the magnitudes of the secretory C–R to the chain and those of the individual components is given in Table XI.

52. Wolowick (80) also investigated conditioned salivations of low magnitudes and difficult experimental unconditioning in a feeble-minded, sickly 6-year old child whose medical history included: measles, chicken-pox, pneumonia with a tubercular infection of the left knee joint, and a number of surgical operations.

TABLE XI

Comparison between the Magnitudes of Salivary C–Rs to a Chain of Stimuli and to the Individual Components in Drops per 30 Seconds

Age of chain C–R	*Stimulus*			
	Chain	*Bell*	*Lamp*	*Tactile*
13	6	7	7	4
18	2	2	3	7
20	1	1	1	1
21	11	3	3	6
24	6	1	1	3
27	8	7	7·	4

At the time of the experiment the child's intelligence is reported to be retarded by 1.5–2 years on the Binet scale, the movements of the left knee joint limited, and the conditioning salivation to the intake of food a few times smaller than normal. An old C–R of 220 trials to a metronome of 120 beats per minute reappeared in the child after three months of no experimentation, the motor response on the first and the secretory on the second trial. But, while the magnitude of the motor C–R was normal, conditioned secretion did not exceed 2–3 drops per 30 seconds even after 70 additional trials with the metronome and 160 trials with an electric bell. Experimental unconditioning was then tried: first, three times by ringing the bell uninterruptedly without reinforcement, and then by similarly ringing the bell every other five or every other 15 seconds. In the first uninterrupted ringing experiment secretion first ceased after three and the mouth was closed after 3.28 minutes, but 34 seconds afterwards the child became excited, cried, and salivation recommenced and continued even when, 35 seconds later, the bell was stopped—the total secretion in five minutes being 18 drops. Similarly, in the second uninterrupted unconditioning experiment the motor response ceased after six minutes 25 seconds, the bell stopped eight seconds later, but the secretion continued for an additional three minutes, reaching a total of 28 drops in eight minutes, although no general excitement of the child was noted. However, in the third uninterrupted experiment the secretion ceased after three minutes with a total secretion of 4 drops, and the mouth was closed after five minutes

four seconds, no further secretory and motor activity being observed for the remaining two minutes 28 seconds of the experiment. In the fourth unconditioning experiment with ringing the bell every other five seconds, salivation continued throughout, reaching a total of 39 drops in five minutes 52 seconds, while the child first closed its mouth after five seconds, but beginning with the fourth ringing of the bell the child's mouth opened and closed every other five seconds, corresponding to the ringing and stopping of the bell, and beginning with the 8th ringing the child became excited and cried. In the fifth experiment with applications of the bell every other 15 seconds secretion ceased first on the 31st stimulation, 15 minutes after the beginning of the experiment, while the motor C–R stopped on the 34th stimulation, one minute and ten seconds later, but on the 38th ringing the child became excited and cried, salivation recommenced and continued even when the experiment was discontinued after a total of 21 minutes and 33 seconds.

53. Dobrovolskaya (43) found that a rowdy 6-year-old encephalitic boy could readily form a positive C–R to a metronome and still more readily uncondition it, but that a negative C–R to a tactile stimulus plus the metronome could not be established until after 30 negative stimulations. Summation of the negative C–R at intervals of 2–3 minutes produced in the child not sleep but great excitement, accompanied by cries, excessive salivation, dyspnoea, and the like; the child also became aroused when he was trained to form a differential C–R between metronomes of 50 and 92 beats per minute, although he remained quiet while developing a differential C–R between metronomes of 50 and 150 beats per minute.

54. Minervina (43) experimented with a difficult case of developing a C–R to a metronome in a 12-year-old hysterical girl who had drunk some anisated ammonia and who at the slightest provocation would either vomit or, if her stomach were empty, become affected by dyspnoea, cyanosis, and muscle-twitching. The metronome had to be introduced first during dancing, the child's favorite performance, but the first two trials with sounding the metronome gave rise to the characteristic excitement, while at the third stimulation the girl fell asleep. Gradually, however, the child became negatively adapted to the metronome until finally combinations of the metronome with food were begun and the C–R was formed after 145 trials, becoming stable after 295 trials; when already stable, the C–R was experimentally unconditioned rather

slowly, requiring 10 consecutive non-reinforced applications for its first disappearance.

55. Norms of the C–R. Norms of central tendencies and variabilities as well as a number of correlations and reliabilities of differences of the magnitudes and latencies of the secretory and motor C–Rs of four children to a metronome have been computed by the reviewer from the data in Juschtchenko's experiment on distraction (33)—excluding the C–Rs on the trials during and immediately after the action of the distraction stimuli—and are presented in Tables XII and XIII. In Table XII are given the ranges, means, S.D.'s, and V's of the magnitudes and latencies of the secretory and motor C–Rs for all children and for each child individually; the reliabilities of the differences between the general V's as well as some correlations between various indices of conditioning are also included in this table. In Table XIII are given the D's, S.D. (diffs.), and D/S.D. (diffs.) between the average magnitudes of the secretory C–R of every two children.

56. As seen from the last four columns in Table XII both the magnitudes and the latencies of the secretory C–Rs are more variable than those of the motor C–Rs, the respective V's being 42.082, 53.411, and 29.603, 36.325, with reliabilities of differences of 6.565 between Vsm and Vsl, and 3.999 between Vmm and Vml. The latencies are also more variable than their respective magnitudes, the V's being 53.411, 36.325, and 42.082, 29.603, with respective reliabilities of differences 6.042 and 4.505. On the other hand, the correlations between the various indices of conditioning, with the exception of the correlation—0.539 ± 0.052—between the magnitude and the latency of the secretory C–R, are negligible, ranging from 0.053 between SM and ML to 0.201 between SL and ML. The tendencies in variability are not without exception in the entries for individual children, child I. O., 15 years old, having the V's of the magnitudes and latencies of both C–Rs nearly equal, and child A. S., 8 years old, having the V for the latency of the motor C–R equal to that of its magnitude. The entries for the individual children also disclose a rather consistent decrement in the magnitude of conditioned salivation with age, the difference between the 4-year old child and the 13 and 15-year old children being respectively 2.14 and 2.16, or a decrement of about 40%, and that between the 8-year old child and the 13 and 15-year old children being 0.79–0.81, or a decrement of 20%, while the difference between the 4 and 8-year old children is 1.353, a decrement of 25%. The relia-

bilities of these differences, as well as those of some smaller differences, are given in Table XIII, from which it is seen that the differences between the 4-year and the 13 and 15-year-olds are fully reliable, the differences between the 4 and 8-year-olds and between the 8-year-old child and the 13 and 15-year-olds are fairly reliable, but the difference between the 13 and 15-year-old children is unreliable.

TABLE XIII

DIFFERENCES AND RELIABILITIES OF DIFFERENCES BETWEEN AVERAGE MAGNITUDES OF SALIVARY C–Rs TO THE SAME STIMULUS IN NORMALLY FED CHILDREN OF DIFFERENT AGES

Measure	*B.K. (4) compared with A.S. (8)*	*B.K. (4) compared with A.E. (13)*	*B.K. (4) compared with I.O. (15)*	*A.S. (8) compared with A.E. (13)*	*A.S. (8) compared with I.O. (15)*	*A.E. (13) compared with I.O. (15)*
D	1.353	2.142	2.159	0.789	0.806	0.017
S.D. (diff.)	0.525	0.529	0.449	0.473	0.368	0.387
D/S.D. (diff.)	2.577	4.049	4.808	1.668	2.190	0.044

57. Comparative norms of variability of the conditioned and subsequent conditioning salivation were also obtained from the experiment of Wolowick (81) on a 10-year old child. The child had a normal conditioning secretion of 9.6 ccs. of saliva in three minutes while consuming 20 gms. of beets, and five established C–Rs to a tactile stimulus, metronome of 120 beats per minute, blue electric lamp, strong and weak bells, of 70, 52, 215, 70, and 51 combinations respectively. Each conditioned stimulus was then applied once on each of seven different days, and the magnitudes of both the conditioned secretion in drops per 30 seconds and subsequent conditioning salivation in ccs. per minute recorded. The results are presented in Table XIV, which has been computed from the experimenter's data. It may be seen from this table that the variability of the conditioned secretion is many times greater than that of the subsequent conditioning secretion, the respective V's being 59.5 and 3.3, and that, furthermore, the correlation 0.157 ± 0.111 between the two secretions is negligible. The much greater stability of the conditioning secretion may also be noted by comparing its general range, 3.7–4.2 ccs., range of means per day, 3.9–4.1 ccs., and range of means per stimulus, 3.9–4.043, with the

TABLE XIV

STATISTICAL COMPARISON BETWEEN CONDITIONED AND SUBSEQUENT CONDITIONING PAROTID SALIVATION IN A 10-YEAR OLD CHILD TO FIVE DIFFERENT STIMULI ON SEVEN DIFFERENT DAYS

Statistical measure	*Conditioned salivation in drops per 30 seconds*	*Subsequent conditioning salivation in ccs. per minute*
Range of means per day	2.0–6.5	3.9–4.6
Range of means per stimulus	3.571–5.571	3.9–4.043
General range	0–10	3.7–4.2
" mean	4.372	3.992
" S.D.	2.6	0.132
" V	59.5	3.3
Correlation and P.E.	0.157 ± 0.111	

respective ranges of 0–10, 2.0–6.5, and 3.571 for the conditioned salivation.

CHAPTER II

Experiments from Chuchmarev's and Lenz's Laboratories

58. *The Chuchmarev Laboratory and Technique.* The Chuchmarev laboratory and technique of human parotid salivary conditioning differ in some ways from those of Krasnogorski and his pupils. The saliometers, a diagram of which appears in the appendix, are made of glass and are held to the duct not by suction but mechanically by special holders which run around to the exterior of the cheek where they end just above the duct in a semi-lunar clamp regulated by a screw. The saliva is measured not in drops but invariably by the amount of displacement of a dye in a tube graduated in mms. and 1.5 mms. in diameter. The conditioned stimulus is applied for 25 seconds, preceding the feeding by 10 seconds, and 20–40 combinations are made in each session lasting 1–2 hours each experimental day. Both conditioned salivation in the 10 seconds preceding the feeding and the salivation in the subsequent 15 seconds during which the conditioned stimulus is applied simultaneously with food are recorded separately, while from time to time the children are not fed and the conditioned salivation is tested for the total 25 seconds. The experimenter is, of course, isolated from the subjects and all stimuli are delivered automatically, although the laboratory itself is apparently not as elaborate as that of Krasnogorski; the children are often provided with paper for their verbal reports.

59. *The Chuchmarev Experiments.* The detailed reports of the Chuchmarev experiments on children have not yet been published, but a general summary of his work is contained in his book "Subcortical Psychophysiology," sent by him to the reviewer. Unlike the Russian physiologists, Chuchmarev is mainly concerned not with brain mechanisms and the physiology of the cerebral hemispheres, but with the relation of conditioning to other overt behavior. Although his conclusions are still too often uncritical, based as they are upon too elementary quantitative treatment of data, on the whole Chuchmarev's general manner of interpreting the results of conditioning seems to be a happy improvement upon traditional Russian ways, digressions into dialectical materialism notwithstanding. The results on various phases of conditioning and the relation of conditioning to school achievement in seven sixth-grade children are presented in Table XV, which is somewhat

TABLE XV

CONDITIONING AND RELATION OF CONDITIONING TO SCHOOL ACHIEVEMENT IN SEVEN SIXTH-GRADE CHILDREN

Phase of conditioning studied	*Child's rank-order in school achievement*						
	1	*2*	*3*	*17*	*22*	*29*	*30*
Trials before first appearance of C–R (conditioned stimulus = bell)	2	4	7	10	14	20	11
Trials before formation of differential C–R (bell from horn)	53	63	67	62	56	72	70
Percentage of magnitude of C–R in terms of subsequent salivation for 15 seconds	10, 7	9, 6	8, 11	4, 6	4, 5	4, 1	5, 2
Magnitude of C–R in mms. when tested for 25 seconds	61, 40	63, 23	79, 50	23, 60	56, 47	57, 47	18, 33
Percentage of magnitude of experimentally unconditioned C–R in terms of the magnitude of the original C–R	10	20	5	41	79	41	75
Salivation in mms. in the subsequent 15 seconds during which conditioned stimulus was applied together with food	166.5 257.5	57.0 52.5	62.5 60.5	92.5 173.0	135.5 158.5	110.5 126.5	340 637
A.D. of the salivation in the subsequent 15 seconds	76.5 67.0	23.0 21.5	26.5 15.0	26.5 36.0	42 51	24 77	71.5 133.5

abridged from the experimenter's table, and in Table XVI, the ρ's of which have been computed from Table XV. The double entries in several rows refer respectively to results at the beginning and at the end of the experimental session. The unreliability of ρ's from such few cases is, of course, fully realized, but interest in these relationships gave rise to so many discussions and conclusions based upon mere inspection that a check even by an unreliable statistical measure seemed desirable.

60. As seen from Table XVI, school achievement correlates highly with speeds of simple and differential conditioning and of experimental unconditioning, as well as with the magnitude of the simple C–R and with its usual decline toward the end of the ses-

TABLE XVI

CORRELATION BETWEEN SCHOOL ACHIEVEMENT AND SOME PHASES OF SALIVARY CONDITIONING AS WELL AS BETWEEN DIFFERENT PHASES OF SALIVARY CONDITIONING IN 7 SIXTH-GRADE CHILDREN

Type of correlation	ρ *and P.E.*
Achievement and speed of formation of simple C–R	0.893 ± 0.050
Achievement and speed of formation of differential C–R	0.643 ± 0.150
Achievement and magnitudes of the C–R at the beginning and end of session	0.714 ± 0.124 0.081 ± 0.265
Achievement and percentage of magnitude of C–R in terms of subsequent salivation in 15 seconds	0.678 ± 0.138 0.812 ± 0.086
Achievement and percentage of magnitude of experimentally unconditioned C–R in terms of the magnitude of the original C–R	0.759 ± 0.107
Achievement and conditioning salivation to food at beginning and end of session	−0.786 ± 0.096 −0.679 ± 0.137
Achievement and relative decline of simple C–R at end of session	0.607 ± 0.163
Speed of formation and magnitude of simple C–R	0.570 ± 0.174 0.438 ± 0.212
Speed of formation of simple C–R and speed of formation of differential C–R	0.536 ± 0.185

sion, but the correlations are negative between achievement and the magnitude of the conditioning salivation. The positive correlation between school achievement and the decline of the C–R toward the end of the session is, of course, also indicated by the high positive correlation between achievement and the absolute magnitude of the C–R at the beginning of the session, and the absence of correlation between the two at the end of the session. The correlations between the speeds of formation of the simple and differential C–Rs and between the speed and magnitude of the simple C–R are also positive and fairly significant.

61. *The Lenz Laboratory.* The Lenz laboratory, detailed diagrams of which are presented in the appendix, has been constructed primarily for the study of conditioned salivation in adults, but evidently may be used as well with children. It has combined some of the better features of both the Pavlov and the Krasnogorski laboratories and, apparently, although not as elaborate, is as free from secondary cues and in some ways more serviceable. The saliometers

are vacuum suction cups with a special third opening for the administration of acids and liquid foods. The saliva is received in a hermetically sealed glass cup, enclosed in a leather case which is strapped to the back of the subject's neck. Measurement of the saliva is taken by the displacement of a dye in a graduated cylinder in the experimenter's room, from which are also pneumatically transmitted the various conditioned stimuli and foods or acids. The experiments last, as a rule, one hour daily; the conditioned precede the conditioning stimuli at first by 5 and later by 30 seconds, while the intervals between successive combinations of the two stimuli are 4–13 minutes, with an average of 7–8 minutes. The magnitude of the C–R is taken as the salivation during 30 seconds of the action of the conditioned stimulus minus the average salivation in the same periods during the preceding 2 minutes of no special stimulation.

62. *Experiments from Lenz's Laboratory.* Segal (67) experimented on simple and differential conditioning in an idiot, an imbecile, and two feeble-minded children, 18[11], 14, 16 and 20[11] years of age respectively; in two subjects one-and-a-half and 2 minutes delay were also tried. The conditioned stimuli were a metronome of 60 beats per minute and a bell from which a metronome of 80 beats and a muffled bell were respectively to be differentiated; in two subjects the conditioned stimuli were also a white lamp of 500 c.p. and a red and green lamp of 25 c.p. which were to be differentiated from a blue lamp of 25 c.p. The results are presented in Table XVII, from which it would appear that stronger stimuli—lamp of 500 c.p. compared with one of 25 c.p.—produced C–Rs of larger magnitudes, and that differential conditioning is rather unstable in subnormal subjects. The difficulty and instability of the simple conditioning of the idiot may perhaps be attributed more to the limitation of the technique brought about by the subject's refractoriness and refusal to have the saliometer attached than to the limitation of his capacity.

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[11] The age limit for this review on children has been arbitrarily taken as 16 years; these cases are, however, included both because of their definite subnormality and because of the desirability of reviewing the experiment in full.

TABLE XVII
SIMPLE, DIFFERENTIAL, AND DELAYED SALIVARY CONDITIONING IN FOUR SUBNORMAL SUBJECTS

Age of subject	*Clinical diagnosis*	*Simple conditioning*				*Differential conditioning*		*Delayed conditioning (magnitudes of C–R with white lamp in successive half min. periods)*
		Conditioned stimulus	*Trials for first appearance*	*Magnitude (divisions in 30 sec.)*	*Remarks*	*Trials for first appearance*	*Remarks*	
14 yrs.	Imbecile	metronome	4	small (1.3–3)	C–R to bell disappeared after 6th and reappeared after 12th trial	3–4	unstable; easily disturbed	2.5, 1.5, 1.0, 1.0; 3.4, 2.4, 5.1, 0.7; 3.1, 2.7, 9.9, 0.9;
		bell	6					
		green lamp	2					
		red lamp	7					
		white lamp	1	3.3				
16 yrs.	Feeble-minded	metronome	8	small (0.5–2.5)		3	unstable	
		bell	8					
20 yrs.	Feeble-minded	metronome	2	small (0.5–3.0)	Disappeared after 2nd, reappeared after 9th trial			
		bell	7					
		red lamp	4		4 months of no experimention, C–R lost			
		metronome	5					
		red lamp	4					
		bell	2					
		white lamp		2.7–9				1.7, 2.3, 2.7, 1.8, 2.5; 2.2, 1.3, 2.5, 11.5, 2.8
18 yrs.	Idiot	Difficulty in forming C–R, appears only sporadically, patient refuses to have saliometer attached.						

CHAPTER III

Experiments from Ivanov-Smolensky's Laboratory

63. *The Ivanov-Smolensky Laboratory and Technique.* In this laboratory conditioning of the so-called "grasping reflex" to some visual stimulus, itself of course a learned response, is studied in children of 4–15 years of age. As a rule the visual conditioning stimulus is the sight of food, although the grasping exploratory reflex has also been similarly investigated. The apparatus with food as a conditioning stimulus, a diagram of which is given in the appendix, consists of a long sloping metallic tube, 55 cms. in length and 3 cms. in diameter, one end of which is in the experimenter's room and the other in the subject's room. The tube, provided with shutters operated by rubber bulbs at both ends, is partly open and covered with a glass plate at the child's end. Pressure of the bulb at the experimenter's end sends food down to the child, who may obtain the sighted food by pressing his bulb. The conditioned stimuli are activated by the experimenter simultaneously with the sending down of food, and the child's C–R of pressing the bulb is registered either on a kymograph or, more recently, on a sensitive manometer, dyanometer, or what is known as a "reflexometer." In the apparatus for the study of the grasping exploratory reflex (diagram in appendix) there is no sloping tube, but the experimenter's connecting a tachistoscope with the subject's bulb lights a lamp in the latter's room. The subject then by pressing his bulb opens a shutter and is enabled to observe a number of kaleidoscopic pictures. The lighting of the lamp, or the conditioning stimulus, is now in the usual way associated with other stimuli and the subject's modified reactions to these other, or conditioned, stimuli studied. Modifications of this apparatus have been used also to study chained C–Rs when one conditioned stimulus is a signal for pressing one bulb, another for pressing another bulb or some other movement, and the food is obtained at the end of the series of reactions; to compare the strength of the food C–R with that of the conditioned withdrawal response to a shock by either simultaneous or separate administration of the respective conditioned stimuli; to study imitation by observing the behavior of a new child placed together with a conditioned child in the subject's room and each child provided with similar apparatus.

64. *Experiments from Ivanov-Smolensky's Laboratory.* Interesting results on individual differences in the formation of positive and negative C–Rs of higher order in thirteen 9–10-year old children have been attained by Novikova (61). The positive conditioned stimulus was an electric bell, sounded for two seconds before the administration of food, while the negative stimulus was a lamp lighted for two seconds before and for two seconds during the action of the bell, the combination of the two stimuli not being, of course, reinforced by food. The main results are given in Tables XVIII, XIX, and XX. In Table XVIII are presented the results on the speed of formation of positive and negative C–Rs, the magnitude and latency of the positive C–R, and the correlation between the speeds of formation of the positive and negative C–Rs. In Table XIX are given in terms of the magnitudes and latencies of the C–Rs two different types of development of negative C–Rs in two children, while in Table XX are given the results on C–Rs of higher order in two children in terms of speed of formation and magnitude of the C–R.

65. As seen from Table XVIII the variability of the speed of formation of the positive grasping C–R is very large, 3–4 times greater than that of the negative C–R and the V's for the trials required for the formation and stabilization of the two C–Rs being respectively 100.183, 134.597 and 25.492, 53.173. The V's of the magnitudes and latencies of the positive C–R could not be computed for lack of data, but would appear to be smaller from the ranges given by the experimenter. The ρ, 0.19, between the number of trials necessary for the first appearance and that for the stabilization of the positive C–R, and the ρ's, –0.024 and –0.125, between the speeds of formation of the positive and negative C–Rs are negligible, but of course not much significance can be attached to correlations derived from so few cases. Equally questionable and unwarranted would appear to be the experimenter's division of the few children into four types: excitable—forming positive C–Rs readily and negative slowly; inhibitable—forming negative C–Rs readily and positive slowly; labile—forming both C–Rs readily; inert—forming both slowly. Characteristic "types" would, however, seem to exist in the manner of the development of the negative C–R as seen from Table XIX, in which the difference between the gradual development of the C–R in child I and the sudden development in child II is rather striking; according to the

TABLE XVIII

Formation of Positive and Negative C–Rs in 13 9–10-Year-Old Children

Child	Trials required for formation				
	Positive C–R		Negative C–R		Remarks
	First appearance	Stabilization	First appearance	Stabilization	
1	3	5	2	2	
2	2	2	5	7	
3	3	39	7	7	
4	17	88	6	6	
5	3	35	7	14	
6	20	20	6	13	
7	14	14	6	23	C–R of second order formed once during negative trials
8	2	2	7	13	C–R of second order formed once during negative trials
9	4	4	6	14	
10	2	2	......	......	C–Rs of second order formed instead of negative C–Rs
11	2	4	......	......	
12	......	......	......	......	C–Rs not stable even after 102–131 trials
13	......	......	......	......	
Range	2–20	2–88	2–7	2–23	
Mean	6.545	19.545	5.778	11.000	
S.D.	6.557	26.307	1.473	5.849	
V	100.183	134.597	25.492	53.173	

Range of magnitude of positive C–R	6.8–1.8 mms.*
Range of latency of positive C–R	0.6–2.4 seconds*
ρ Between number of trials required for first appearance and for stabilization of positive C–R	0.190
ρ Between number of trials required for first appearance of positive and negative C–Rs	–0.024
ρ Between number of trials necessary for development of stable positive and negative C–Rs	–0.125

* Given by experimenter.

TABLE XIX

TYPES OF DEVELOPMENT OF NEGATIVE C–Rs IN TWO NINE-YEAR-OLD CHILDREN

Number of negative trials	*Child I*		*Child II*	
	Magnitude of C–R in mms.	*Latency of C–R in seconds*	*Magnitude of C–R*	*Latency of C–R*
1	9	2.8	9	3.0
2	12	2.5	10	3.1
3	7	2.9	9	3.0
4	6	3.0	9	2.7
5	3	3.2	9	3.0
6	2	4.2	0	0
7	0	0	0	0

TABLE XX

FORMATION OF C–Rs OF HIGHER ORDER IN TWO 9–10-YEAR-OLD CHILDREN

Order of C–R	*Stimulus*	*Child I*		*Child II*	
		Trials before first appearance	*Magnitude of C–R in mms. of pressure*	*Trials before first appearance*	*Magnitude of C–R in mms. of pressure*
First	Bell	2	6.38	2	9.0
Second	Lamp of 25 c.p.	18	7.00	3	8.5
Third	Metronome of 200 beats per minute	6	8.50	6	7.1
Fourth	Sight of red circle	4	8.89	11	7.8

experimenter, 7 children had this "sudden" type of developing a C–R, while the remaining two children had the "gradual" type of development. The experimenter also reports that a decrement in a positive C–R, applied 20–60 seconds after the negative C–R, was observed in some children, while an increment was observed in other children with similar intervals between the application of the two C–Rs.

66. To a special "type" also belong, according to the experimenter, the two children whose interesting results on the formation of C–Rs of higher order to previously indifferent stimuli are given in Table XX. As seen from this table, these children formed C–Rs of higher orders rather readily and the magnitudes of the higher C–Rs differed little from those of the original C–R. Attempts to experimentally uncondition the C–Rs in these children as well as to form differential and negative C–Rs are reported to have been very difficult or altogether unsuccessful. Both children first failed to develop the negative C–R; one child could neither uncondition the C–R to the bell after 33 non-reinforced applications nor develop a differential C–R after 75 negative applications, while the other child formed a differential C–R to the bell only after 51 negative applications and a negative C–R only after the development of the differential C–R.

67. Gackell (17) in a way repeated the experiment of Novikova on six 11–13-year old hysterical children. The positive conditioned stimulus was the lighting of a lamp for two seconds before the administration of food, while the negative conditioned stimulus was the sounding of a bell one second before the lamp. All children formed both positive and negative C–Rs, the former after respectively 2, 6, 18, 27, 32, and 92 trials and the latter after 2, 2, 70, 77, 100, and 100 trials; in three of the children C–Rs of the second order appeared in 36% of trials before the final formation of the negative C–R. The experimenter's conclusions, however, that hysterical children form C–Rs more slowly and have a greater tendency towards the formation of C–Rs of the second order than normal children are far from warranted from her data, as the differences between her results and those of Novikova are neither based upon a sufficient number of cases, nor are they very marked.

68. Sinkievich (73) compared the conditioning and dominance of the grasping C–R to food and the withdrawing C–R to liminal shock in four 9–10-year old children. First, each child formed a C–R of grasping a rubber bulb with the right hand upon the lighting of a red lamp of 16 c.p. and a C–R of withdrawing the left hand upon the lighting of a green lamp of the same power, both C–Rs being recorded on the same scale of the reflexometer. Then, when the C–Rs were firmly established, appearing 10 times in succession, the lamps were lighted simultaneously for 10 trials, and the responses of each child noted; the children's reaction to a yellow lamp of 16 c.p., given before and a day after the simultaneous ap-

plications of the red and green lamps, were also tested. The results are presented in Table XXI, from which it may be seen that in

TABLE XXI

Comparative Speed of Formation and Dominance of Grasping C–R to Food and Withdrawing C–R to Shock in Four 9–10-Year-Old Children

Child	*Trials required for appearance of C–R*		*Child's responses to simultaneous applications of conditioned food and shock stimuli*			*Child's response to yellow lamp*	
	Food	*Shock*	*Grasping alone*	*Withdrawing alone*	*Grasping and withdrawing*	*Before* Simultaneous applications of shock and food stimuli	*After* Simultaneous applications of shock and food stimuli
1	157	35	3	7	......	Grasping	Withdrawing
2	2	22	5	......	5	Grasping	Grasping
3	130	70	......	8	2	Grasping and withdrawing	Withdrawing
4	6	8	......	......	10	Grasping and withdrawing	Grasping and withdrawing

9–10-year old children there is a wide range, 2–257, in the speed of formation of the grasping C–R to food, a smaller range, 8–70 trials, for the C–R to shock, and that apparently even a liminal shock C–R is dominant over a grasping food C–R.

69. A much more extensive experiment on comparing a number of phases of conditioning the grasping and withdrawing responses to various auditory stimuli was made by Korotkin (35) in nine 9–10-year old children. Speed of formation and stabilization of simple and differential C–Rs, experimental unconditioning, and the effect of extraneous external stimuli were investigated for both C–Rs separately, but no tests on the simultaneous applications of the shock and food conditioned stimuli were made. The shock was always 0.5–1.0 cm. above the threshold and its response was recorded on the same scale of the reflexometer as that of the food. The intervals between the beginning of the applications of the conditioned and conditioning stimuli were 1–2 seconds, of the extraneous and conditioned stimuli 0.5 seconds, and between successive trials 10–35 seconds. In experimental unconditioning the intervals between successive non-reinforced applications were 15 seconds for the food and 10 for the shock experiments; in differential condi-

tioning every non-reinforced application of the negative stimulus alternated with 1–4 reinforced applications of the positive stimulus. The sequence in the food experiments was: the formation of a C–R first to a whistle and then to *a*♯ (small, unaccented octave on the f♯ harmonica), the differentiation of the C–R to *a*♯ and *c*♯, the experimental unconditioning of *a*♯, the testing of the effect of the sounding of an automobile horn on the restored C–R to *a*♯. In the shock experiments, which were performed two weeks after the food experiments, first a C–R was formed to a toy horn and to *d*♯, then the C–R to *d*♯ was differentiated from *b*♯ and later experimentally unconditioned, and finally the effect of the automobile horn on the restored C–R was tested.

70. The results are presented in Tables XXII and XXIII and in Figure I, from which it may be seen that there is no reliable dif-

TABLE XXIIb

EXPERIMENTAL UNCONDITIONING AND EFFECT OF EXTRANEOUS STIMULATION ON THE GRASPING RESPONSE TO THE SIGHT OF FOOD AND WITHDRAWING FROM AN ELECTRIC SHOCK IN NINE 9–10-YEAR-OLD CHILDREN

Number of child	*Non-reinforced trials before disappearance of C–R*				*Effect of Automobile Horn on*	
	One disappearance		*3 successive disappearances*		*Food C–R*	*Shock C–R*
	Food C–R	*Shock C–R*	*Food C–R*	*Shock C–R*		
1	7	7	......	......	Increased both magnitude and latency	Increased magnitude
2	......	......	......	......		
3	7	......	14	2	Increased latency; decreased magnitude	Increased magnitude; decreased latency
4	13	(Did not disappear at 51)	......	......		
5	4	(Did not disappear at 38)	......	......		
6	......	......	......	......		
7	6	19	......	......		
8	8	11	......	......		
9	7	3	14	......		

TABLE XXIIa

SIMPLE AND DIFFERENTIAL CONDITIONING OF GRASPING RESPONSE TO THE SIGHT OF FOOD AND WITHDRAWING FROM AN ELECTRIC SHOCK IN NINE 9–10-YEAR-OLD CHILDREN

Number of child	*Trials required for formation of simple C–Rs*								*Non-reinforced trials for formation of differential C–R*			
	First appearance				*Stabilization*				*First appearance*		*Stabilization*	
	Food C–R		*Shock C–R*		*Food C–R*		*Shock C–R*		*Food*	*Shock*	*Food*	*Shock*
	Whistle	*a♯*	*Horn*	*d♯*	*Whistle*	*a♯*	*Horn*	*d♯*	*a♯ from c♯*	*d♯ from b♯*	*a♯ from c♯*	*d♯ from b♯*
1	2	2	2	2	2	2	2	2	8	17	46	32
2	6	2	13	2	20	6	45	8	15	33	62	(Not stable at 88)
3	6	4	4	1	2	2	22	52	6	......	19	......
4	1 (Metronome as conditioned stimulus)	3	3	2	24	3	33	2	5	(Not formed after 33)	12	......
5	2	2	3	4	2	2	17	4	5	2	21	39
6	6	2	3	1	6	2	32	13	9	(Not formed after 25)	9	......
7	6	......	6	......	2	......	36	......	27	......	41	......
8	8 (Metronome)	2	5	2	21	2	5	2	2	52	8	77
9	2	......	26	......	2	......	107	......	5	12	19	12

TABLE XXIII

Comparison between Speed of Conditioning of Grasping and Withdrawing Responses in Nine 9–10-Year-Old Children

Statistical measure	*Trials required for formation of simple C–R*			
	First appearance		*Stabilization*	
	Food C–R	*Shock C–R*	*Food C–R*	*Shock C–R*
Range	2–8	2–26	2–24	2–107
Mean	3.5	4.938	6.25	24.063
S.D.	2.092	6.124	7.554	25.552
V	59.771	124.018	120.864	106.188
S.D. (av.)	0.523	1.531	1.889	6.388
D	1.438		17.813	
S.D. (diff.)	1.618		6.662	
D/S.D. (diff.)	0.889		2.674	
Correlation between latency and magnitude of food C–R			0.139 ± 0.087	
Correlation between latency and magnitude of shock C–R			-0.595 ± 0.058	

ference between the speed of the formation of the grasping and withdrawing C–R, but that the withdrawing C–R is more variable in the speed of its formation, less readily stabilized, and also apparently on the whole less readily experimentally unconditioned and differentiated than the grasping C–R, while the course of the development of differentiation is extremely irregular for both C–Rs.

71. Fadeyev (15) reports the formation of C–Rs to chains of visual stimuli in seven 9–10-year old children. The chain consisted of 3–12 flashes of differently colored electric bulbs of 2.5 volts, placed along a straight line 3 cms. from each other, the flashes lasting one second each, with intervals of one second between them, and the last flash being reinforced by food; the various orders of presenting the stimuli had also to be differentiated from each other. The results show marked individual differences: some children easily formed and differentiated the visual chains; others could not do so even after hundreds of trials; also, some children gave the C–R at the end of the chain while others responded to each flash.

Using the Ivanov-Smolensky method and taking kymographic records of the grasping responses, Bayne, Winsor, and Winters (2, 3)

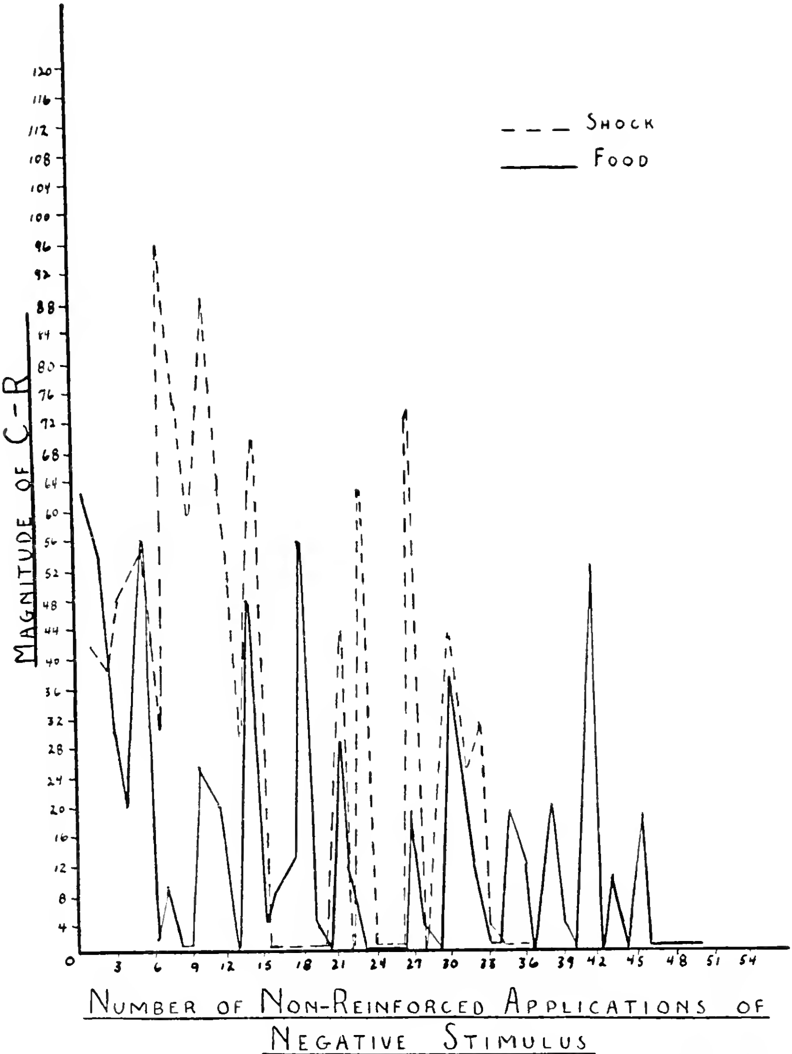

Fig. I. Development of Differential C–R's to Auditory Stimuli (a: from c: and d: from b:) with the Grasping Response to the Sight of Food and the Withdrawing Response to Shock as the Conditioning Responses.

report the establishment of C–Rs to the sound of a metronome and of a buzzer and to the flash of a light in two 6-year old children after 8–10 trials, but state that 200–300 trials were required in a 4-year old child.

72. The following experiments have been reported by Ivanov-Smolensky (22, 25) from his laboratory, but no detailed results of them have, however, been available. Aksenov formed a C–R with a triple chain response—pressing a bulb, then another, and then raising a lever—to a light by first establishing separate C–Rs of pressing the first bulb to a light, the second to a sound, and raising the lever to a tactile stimulus, the stimuli following each other at short intervals and the light being always the first of the series. Kapustnikov found that 7–8-year old children who had formed C–Rs to sound or light would also give the response to the words "sound" or "light" as auditory stimuli; that, conversely, C–Rs to the sound of the words generalized to actual sounds or light as well as to the exposure of a card on which the words "sound" or "light" had been printed; and that experimental unconditioning of the C–Rs to actual sound or light caused the disappearance of the response to their symbols. Novikova studied in 6–8-year-old children various phases of a special C–R consisting of associating feeding with bending the children's forearms, the bending being done in the period of training by means of a special apparatus. Ivanov-Smolensky further reports generalization of a C–R in a 4-year old child from the sound of *do* and pressing a flat black bulb to the sound of *la* and pressing a brown pear-shaped bulb, as well as imitation, or C–Rs of higher order, in 4–6-year old children watching conditioned children press a bulb to conditioned stimuli, the imitation, or C–Rs, being formed faster in the observing children when the pressure of the conditioned children was reinforced by food.

CHAPTER IV

Experiments from Bekhterev's Laboratory

73. *The Bekhterev Technique and Laboratory.* In this laboratory experiments have been conducted on children of two different age groups—school children, and infants under one year—and the conditioning responses and techniques differed with each of the two groups. With infants the conditioning responses have been food-seeking movements (rhythmical sucking movements, opening of mouth, and, later, characteristic head, limb, and trunk movements), the movements being sometimes recorded kymographically but usually only observed by the experimenter; while the general techniques used have been of two main types: the "breast" or "natural" and the "bottle" or "laboratory" techniques. In the former, in which, as the name indicates, the infants are breast fed, the conditioned stimuli are applied regularly at each feeding, and no attempt is made to regulate or interfere with the feeding, even though the durations of the conditioned stimuli are held constant—45 seconds, 15 before and 30 after the beginning of the nursing. In the latter, the infants are bottle fed, the conditioned stimuli are given only during the experimental feeding periods—usually once a day—, the duration of each feeding is held constant—20 seconds—, and a few feedings are made each experimental period. In neither technique is the experimeter adequately isolated from the infants' room and the control of secondary cues is rather elementary, but of course, these factors are most requisite only in modality problems. Interesting results have also been obtained in the laboratory by careful testing of the infants' natural food C–Rs: odor of milk, holding in a characteristic feeding position, moving the infant's hand toward its face, and the like.

74. With school children the standard technique is still the use of an electric shock, now nearly always applied to the fingers of the subjects, as the conditioning stimulus. The main features of this technique are both too simple and too well known to require detailed description. Newer modifications and improvements, some diagrams of which are given in the appendix, include: complete isolation of the experimenter from the subjects' room, simultaneous stimulation of the fingers of both hands, recording time by a Hipp chronoscope, recording the responses by manometers, keys for acti-

vation of 42 different visual and 7 different auditory stimuli, revolving apparatus for automatic changes of colored filters in front of electric lamps, time relays for automatic regulation of the duration and intervals between stimuli. The conditioned stimuli in these shock experiments as a rule precede the shock by 2–3 seconds, the intervals between successive combinations of conditioned stimulus and shock are 15–40 seconds, while altogether 15–60 combinations are made each experimental period.

75. Recently, however, the Bekhterev laboratory has been reporting experiments on school children with—what is called—the use of words or commands as conditioning stimuli. In these experiments the conditioned stimuli precede in the usual manner the experimenter's command to the subject to perform some simple reaction: "raise your finger," "lift your foot," "bend your head," "press the key," and the like. The specific command or, when the subjects know their tasks well, just "go," is repeated at each trial, and a C–R is considered formed when the children make the required reaction without the experimenter's command or signal. This procedure has been offered as an alternate and auxiliary technique for the study of conditioning processes in children, particularily in those who either completely fail to form stable C–Rs to shock or form them with great difficulty. The reviewer doubts, however, the legitimacy of the inclusion of these experiments under conditioning, and would rather class them with similar psychological experiments on incidental association.[12]

76. *Experiments on School Children with Shock as the Conditioning Stimulus.* Osipova's Experiment. By far the most extensive single experiment was performed by Osipova (63) on the speed of formation of the C–R in different groups of school children, 7–19 years of age. Altogether, 327 children were used: 67 normal boys, 75 normal girls, 58 subnormal boys, 64 deaf-mute boys and girls, and 63 blind boys and girls; 14 children refused to be submitted to the shock and were excused. The conditioned stimulus for the deaf-mutes was a flash of an electric lamp of 5 c.p. but for the remaining groups the sound of a bell of 826 d.v., while the magnitude of the shock varied with each child, the distances between induction

[12] It would seem desirable to restrict the concept of conditioning to such associations in which the conditioning reaction is phylo- and onto-genetically older and organismically simpler than the conditioned reaction, thus making conditioning the principle of building up the complex from the simple and the new from the old; such a restriction excludes the use of words as conditioning —but by no means as conditioned—stimuli.

coils ranging from 1 to 12 cms., with an average of 6.89 and an S.D. of 2.46. Twenty trials, with intervals of 15–45 seconds between them, were made each experimental period, and the C–R was considered established if it was elicited for 4–5 successive trials without reinforcements or retained for a few weeks without additional training. The large number of subjects used apparently did not readily permit spending more than 1–2 experimental periods on each child, and, after 20–40 trials, the experiments were as a rule discontinued even with those children who did not yet form a stable C–R, although in some subjects 60, 80, 100, and 120 trials were tried. Account has, however, been taken of these unevenly incomplete cases, and all results, statistically treated, are presented in Tables XXIV–XXVI and in Figures II, III, and IV.

77. In Table XXIV are given the central tendencies and variabilities of the number of trials required for the formation of the C–R in the various groups and subgroups, the incomplete cases having been included in the computation of the medians but, of course, not of the means and S.D.'s. In Table XXV are presented the differences and reliabilities of the differences between the means and the proportions of the groups; here, again, the data on the proportions are more complete and should be given greater weight. Table XXVI contains the correlations between the speed of formation of the C–R and the several traits of the groups, the product-moment for intelligence not having been computed for lack of scores. Figures II, III and IV indicate roughly the type of the distribution of trials required for the formation of the C–R in the several groups and in the total population.

78. The chief points that may be learned from Tables XXIV–XXVI and Figures II, III and IV are: that subnormal children form stable C–Rs to shock faster than normal children of the same age (correlations substantial and differences between the central tendencies reliable); that there is some evidence that girls form the C–Rs faster than boys (correlations low and differences somewhat reliable); that deaf-mute and blind children, as well as normal children, over 14 years of age do not form C–Rs to shock readily—in less than 20–40 trials—; that there is little, if any, relation between age and speed of formation of C–R in children—both normal and subnormal—7–14 years of age; that there is indication that the complete curve of the distribution of trails for the formation of the C–R is either J-shaped or very positively skewed.

TABLE XXIV

SPEED OF FORMATION OF A C–R WITH SHOCK AS THE CONDITIONING STIMULUS IN DIFFERENT GROUPS OF SCHOOL CHILDREN (CONDITIONED STIMULUS IN ALL BUT THE DEAF MUTE A BELL OF 826 D.V.)

No. of group	Type of group	Age range	Total no. of cases	Number of cases conditioned	Trials required for formation of the C–R: Mean	S.D.	$\frac{S.D.}{\sqrt{N}}$	V.	Median	σ (P. 50)
I	Normal boys	8–19 yrs.	75	47	14.13	14.87	2.17	105.24	20	5.77
II	Normal girls	7–18	67	56	12.48	15.14	2.02	121.31	8	6.11
Ia	Normal boys	8–14	56	41	10.98	10.55	1.64	96.08	9.5	6.68
IIa	Normal girls	7–14	60	54	12.35	15.37	2.092	124.45	7	6.45
I + II	Normal boys and girls	7–19	142	103	13.04	15.04	1.418	115.34	11	4.19
(I + II)a	Normal boys and girls	7–11	64	53	12.83	16.5	2.27	128.6	7	6.25
(I + II)b	Normal boys and girls	12–19	78	50	13.15	13.66	1.93	103.87	20	5.77
(I + II)c	Normal boys and girls	7–10	50	39	13.03	17.65	2.83	135.46	[illegible]5	7.07
(I + II)d	Normal boys and girls	11–18	89	63	13.27	12.19	1.548	91.86	15.5	5.29
(I + II)e	Normal boys and girls	7–14	116	95	11.76	13.52	1.387	114.97	8	4.64
III	Subnormal boys	7–14	58	58	5.53	3.407	0.447	61.61	4	6.56
IV	Deaf mute boys and girls	11–18	64	13	11.31	7.35	2.04	64.99		
V	Blind boys and girls	9–18	63	4	Range = 4–7					
(I + II)f	Normal boys and girls	14–19	28	8	Range = 7–80					

TABLE XXV

RELIABILITIES OF DIFFERENCES IN SPEEDS OF FORMATION OF A C–R WITH SHOCK AS THE CONDITIONING STIMULUS IN DIFFERENT GROUPS OF SCHOOL CHILDREN

Groups compared		*Differences between means*			*Differences between proportions*		
No. of groups	*Description*	*D*	σ/*diff.*	*D*/σ/*diff.*	$P.50-P_{p1}$	$\sigma(P.50-P_{p1})$	$P.50-P_{p1}/\sigma(P.50-P_{p1})$
I–II	Normal boys with normal girls, 7–19 years of age	1.65	2.97	0.56	14.33	8.109	1.765
Ia–III	Normal with subnormal boys, 8–14 years of age	5.45	2.165	2.52	32.14	8.285	3.98
IIa–III	Normal girls with subnormal boys, 8–14 years of age	6.82	2.515	2.71	17.33	8.892	1.95
(I+II)c–III	Normal boys and girls with subnormal boys, 7–14 years of age	6.23	1.98	3.146	24.14	7.679	3.14
(I+II)b–(I+II)a	Normal boys and girls, 7–11 years of age, with boys and girls 12–19 years of and girls 12–19 years of age	0.32	2.98	0.107	21.67	8.066	2.69
(I+II)d–(I+II)e	Normal boys and girls, 7–10 years of age, with boys and girls 11–18 years of age	0.24	3.125	0.077	22.91	8.497	2.7
IV–(I+II)d	Normal boys and girls with deaf-mute boys and girls, 11–18 years of age	1.96	2.55	0.77	34.44	6.97	4.9

TABLE XXVI

CORRELATIONS BETWEEN TRIALS REQUIRED FOR FORMATION OF A C–R TO SHOCK AND AGE, INTELLIGENCE, SEX, AND DEAF-MUTISM OF SCHOOL CHILDREN

Trait correlated	*Group used*	*No. of cases*	*Type of correlation*	*Coefficient of correlation and its P.E.*
Age	Normal, 7–19 yrs.	142	Product-moment	0.358 ± 0.033
"	Normal, 7–14 yrs.	116	" "	0.029 ± 0.0425
"	Subnormal, 7–14 yrs.	58	" "	−0.079 ± 0.06
"	Normal with dichotomy at 10 yrs.	50 + 89	Biserial r	0.370 ± 0.0769
"	The same with dichotomy made at 11 yrs.	67 + 75	" "	0.354 ± 0.0762
"	The same with dichotmy at 14 yrs.	116 + 28	" "	0.716 ± 0.0641
"	The same with age dichotomy at 11 yrs. and speed dichotomy at 20 trials	67 + 75	Tetrachoric r	0.324 ± 0.0823
"	The same with age dichotomy at 14 yrs. and speed dichotomy at 20 trials	116 + 28	" "	0.789 ± 0.0533
Intelligence	Normal and subnormal, 8–14 yrs.	56 + 58	Biserial r	0.540 ± 0.0789
"	The same 2 groups with speed dichotomy at 4 trials	56 + 58	Tetrachoric r	0.644 ± 0.0701
Sex	Normal, 7–19 yrs.	75 + 67	ϕ	0.196 ± 0.06
"	" " "	" "	C. C.	0.1872 ± 0.054
"	" " "	" "	χ^2	5.154; P = 0.025
"	" " "	" "	Biserial r	0.225 ± 0.884
Deaf-mutism	Normal and deaf-mute groups 11–18 yrs.	89 + 64	ϕ	0.407 ± 0.0958
			C. C.	0.378 ± 0.065
			χ^2	25.37; P < 0.01
			Biserial r	0.573 ± 0.0654

79. Other Experiments. Iliynsky (19) seems to have confirmed the results of Osipova on the relation of age and sex to the speed of formation of the shock C–R. He experimented on 51 adolescents—boys 13–15 and girls 12–15 years of age; 17 pre-adolescents—boys 10–12 and girls 10–11 years; and 13 post adolescents—boys and girls 16–18 years of age. The conditioned stimuli were notes on the f♯ harmonica and flashes of electric lamps, and the C–Rs were tested after each 6–10 trials. The experimenter's report does not contain detailed results, but has some representative measures of the groups, which are presented in Table XXVII and from which it would appear that the older children formed the

C–R less readily than the younger and the boys less readily than the girls.

80. The experimenter also states that simple shock C–Rs are more generalized in adolescent boys than in girls of the same ages or in younger boys, but that the adolescent boys form differential C–Rs faster although their differentiation is less complete—more disappearances of positive C–Rs. In another experiment (21) Iliynsky reports the formation of a successive C–R with a pause

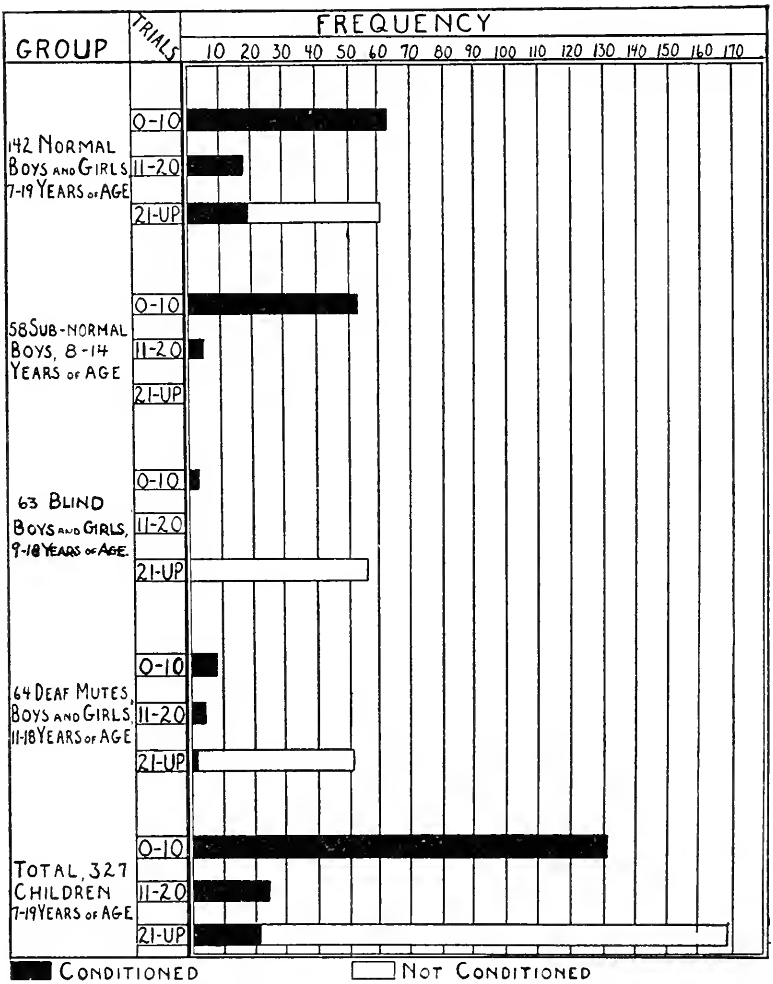

FIG. II. Trials required for Formation of C–R to Shock in Normal, Subnormal, Deaf-Mute, and Blind School Children.

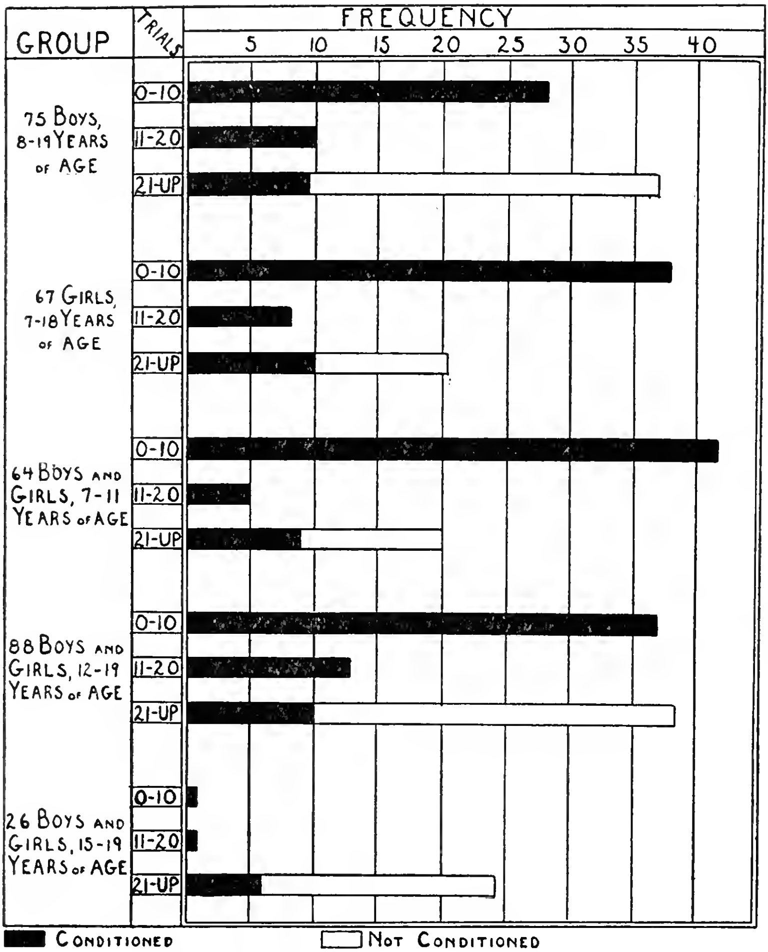

FIG. III. Trials Required for Formation of a C–R to Shock as Related to Age and Sex of 142 Normal School Children.

of 5–20 seconds in 12 of 25 subnormal boys, but the reviewer regrets that the gross inaccuracies of the report preclude it from being fully reviewed.

81. Sorokhtin (77) investigated the process of conditioning to liminal shock in eight 9–16 year-old children of the so-called "inhibitable" type, or those who supposedly either cannot altogether form C–Rs to shock or cannot develop them with any significant degree of stability. Each child received 150–220 combinations of liminal shock with the flash of a red lamp of 75 c.p., the trials be-

ing distributed over 4–6 experimental sessions and kymographic records being taken of both finger movements and respirations; the effect of extraneous auditory and visual stimuli was also tried from time to time. The main results are presented in Table XXVIII, from which the difficult conditioning is rather apparent, although,

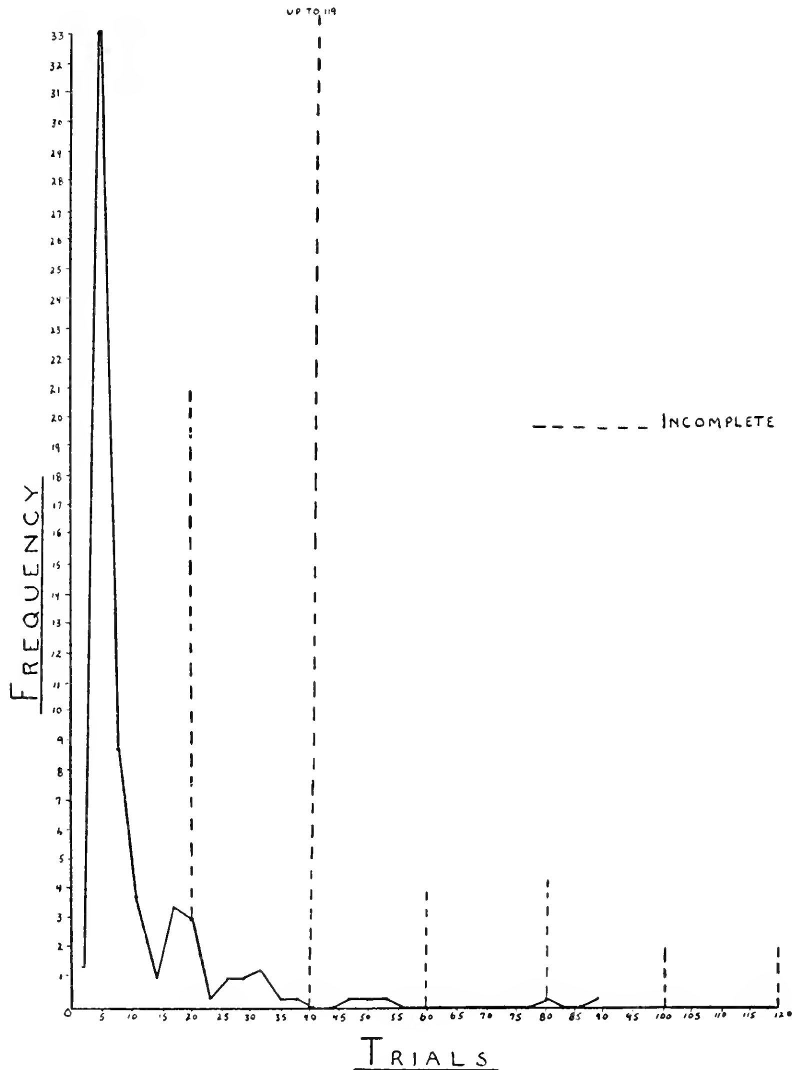

Fig. IV. Distribution of Trials Required for Formation of a C–R to Shock in 178 School Children.

TABLE XXVII

SPEED OF FORMATION OF A C–R TO SHOCK IN 81 NORMAL CHILDREN, 10–18 YEARS OF AGE

Age and sex of children	*No. of cases*	*Magnitude of shock (cm. distance between coils)*	*Percentage of cases conditioned**	*Trials required for conditioning*
Boys and girls, 10–12 yrs.	17	10.5	84	16 for the boys; 9 for the girls
Boys, 13–15 yrs.	34	9.0	40	39
Girls, 12–15 yrs.	17	10.0	47	18
Girls, 16–18 yrs.	8	6.0	40	30
Boys, 16–18 yrs.	5	5.0	one boy	33

* The following is an example of the crude inaccuracies of computed measures often found in reports of Russian experiments; a number of these are undoubtedly printers' errors.

TABLE XXVIII

DIFFICULT CONDITIONING OF SHOCK IN EIGHT 9–16-YEAR-OLD CHILDREN. (NUMBER OF TRIALS 150–220)

Name of Child	*Age*	*Trials before First Appearance of C–R*	*Type of First C–R*	*Trials before First Disappearance of C–R, or "Inhibition"*	*Percentage of Failures in Order of Experimental Sessions*
M. S.	16	3	Regular	12	I = 69; II = 90; III = 100; IV = 0; V = 100
T. M.	15	1	"	3	100% in All Sessions
A. V.	14	2	Micro*	1	I, 7 Regular C–Rs; Remaining Sessions 100% Failure
N. S.	11	1	Micro and Extra**	1	100% in All Sessions
O. S.	16	1	Extra	1	88 in First 3 Sessions; IV = 0; V and VI = 91
E. F.	9	Did Not Appear	......	......	......
L. R.	16	" " "	......	......	......
A. S.	14	" " "	......	......	......

* Just slightly releasing but not lifting finger.
** C–R to no apparent external stimulus.

of course, the possibility of forming a stable C–R with more trials is probably not excluded.

82. Other results not contained in the table are as follows: in a large number of cases the children failed to lift their fingers even to the shock itself, while in some other cases they pressed the electrodes instead of releasing them upon the application of the shock or the conditioned stimulus; marked irregularities in the respiration curves were often noted during the failures of the motor C–R, although in certain cases respiration was regular even when the motor C–R appeared; the application of extraneous auditory and visual stimuli elicited a few times the motor C–R, even when the trained conditioned stimuli were ineffective.

83. In another experiment (76) Sorokhtin studied the conditioning processes in two so-called "cyclic" children in whom periods of "excitation," or ready appearances of the C–R, alternate with periods of complete or partial "inhibitions," or failures. One child, 13 years old, who first formed the C–R after 3 trials is said to have passed, in the course of 7 experimental periods, through the following 5 cycles: first, 57% "inhibitions," then 100% irradiated "excitation"—C–R elicited even by stimuli similar to the conditioned stimuli,—next, 72% "inhibitions," and finally 100% irradiated "excitation" followed again by 60–100% "inhibitions." In another child, 11 years old, who first formed the C–R after 6 trials, a period of 63% of "differential excitation"—C–R elicited only by conditioned stimulus—is said to have been succeeded by 100% "inhibition," after which followed respectively: "irradiated excitation," 94% "inhibition," and 92% "differential excitation."

84. Attempts to "disinhibit," or cause to reappear, conditioning and conditioned motor responses to shock were made by Minut-Sorokhtina (58) in twenty-six 11–13 year-old children. The children were experimented upon for 2–5 sessions, each session lasting 20–25 minutes and consisting of 40–50 combinations of the shock to the right hand with the flash of an electric lamp. When now, after a number of combinations, the conditioned or conditioning withdrawal response failed to appear, the following were sometimes effective. The application of extraneous stimuli was effective 8 times in 6 subjects; administration of the shock alone worked in 21 subjects in 36 of 108 cases; while previous stimulation of the left hand with the shock, tried in 11 subjects, was successful in

three subjects, partly successful in three others, and altogether failed in the remaining five subjects.

85. Bekhterev and Polonsky (5) report the appearance of a fine differential C–R to a note *c* on an f♯ harmonica in an 11-year old child without any training by the method of contrasts. When the C–R, which first appeared on the 8th and became stable on the 22nd trial, was tried in the third experimental period, it was found to be very specific, being elicited only by the note *c* and not by its neighboring notes: *d, e, f,* and *g;* however, this differentiation disappeared as suddenly as it came, breaking down at the end of the 4th experimental period and not being further re-established in 24 periods.

86. Kantorowitz (34) studied the effect of continuous physical and mental work, or fatigue, upon well-established simple and differential C–Rs to electric lamps in three 12, 15, and 16-year-old children. The mental work consisted of mentally adding or subtracting consecutive ascending or descending 3-place numbers, while the physical work was the pulling of the handle of a dynamometer, either continuously or rhythmically, to the sound of a metronome of 40 beats per minute. The entire procedure of the experiment was as follows: first, the children were given a rest of

TABLE XXIX

THE EFFECT OF MENTAL WORK (MENTAL ARITHMETIC) UPON SIMPLE AND DIFFERENTIAL C–RS IN THREE SUBJECTS, 12–16 YEARS OF AGE

Age of child	*Trial at which C–R first appeared*	*Trial at which experiment began*	*Duration of work*	*Effect upon simple C–R (percentage of appearance to the conditioned stimulus)*		*Effect upon differential C–R (percentage of appearance to other than conditioned stimuli*	
				Before work	*After*	*Before work*	*After*
16	9	125	32 min.	100	70	0	0
Same child	"	"	30 "	100	83	10	0
15	16	175	39 "	100	85	0	25
Same child	"	"	36 "	100	80	0	20
12	"	357	32 "	100	88	0	55
Same child	"	"	42 " 30 "	100 100	100 88	12 5	89 34

half an hour, then their C–Rs were tested, next they were subjected to physical and mental work until definite decrements in their output were observed, finally their C–Rs—both simple and differential—were retested. The results are presented in Table XXIX, from which it would seem that the continuous mental work for 30–40 minutes disturbs both the simple and differential C–R, while the physical work, the experimenter states, has no effect, although, of course, the cases are too few to make this generalization conclusive.

87. *Experiments on School Children with Words as the Conditioning Stimuli.* (Incidental Association.) Oparina (62) experimented on children, 7–16 years of age, divided into groups of 3–5 each. Upon the experimenter's signal "go" the children would perform some simple, previously designated and practiced, reaction, while the conditioned stimuli, an electric bell or lamp, were being applied. The reactions were different for each member of a group, and the children were, of course, not informed of the conditioned stimuli and were forbidden to talk during the experiment. Not more than 30 trials were made each experimental period, and the C–R, or association, was considered established if the desired reaction was given for 6–7 successive trials without the experimenter's "go." The results are presented in Table XXX and in

TABLE XXX

FORMATION OF A C–R WITH WORDS AS THE CONDITIONING STIMULI (INCIDENTAL ASSOCIATION) IN GROUPS OF CHILDREN, 7–16 YEARS OF AGE

Type of groups	*Number of groups*	*Number of C–Rs formed*	*Trials required for formation*			
			Mean	*S.D.*	*Median*	*Skewness* $\frac{3\,(M.-Med.)}{\sigma}$
Boys	25	46	10.75	2.528	10	—
Girls	24	48	10.87	2.577	10	—
Both	49*	94	10.81	2.543	10	0.9556

"r" between age and speed of formation = 0.556 ± 0.0475

* 3 groups did not form the association.

Figure V, from which it may be seen that the speed of formation of this type of C–R correlates negatively with age but zero with sex and that the distribution of trials required for the formation of

the C–R is apparently normal. It may be noted, however, that although the reactions for each member of the groups were different, the formation of the C–R obviously depended not only on conditioning or association but also on imitation and social facilitation

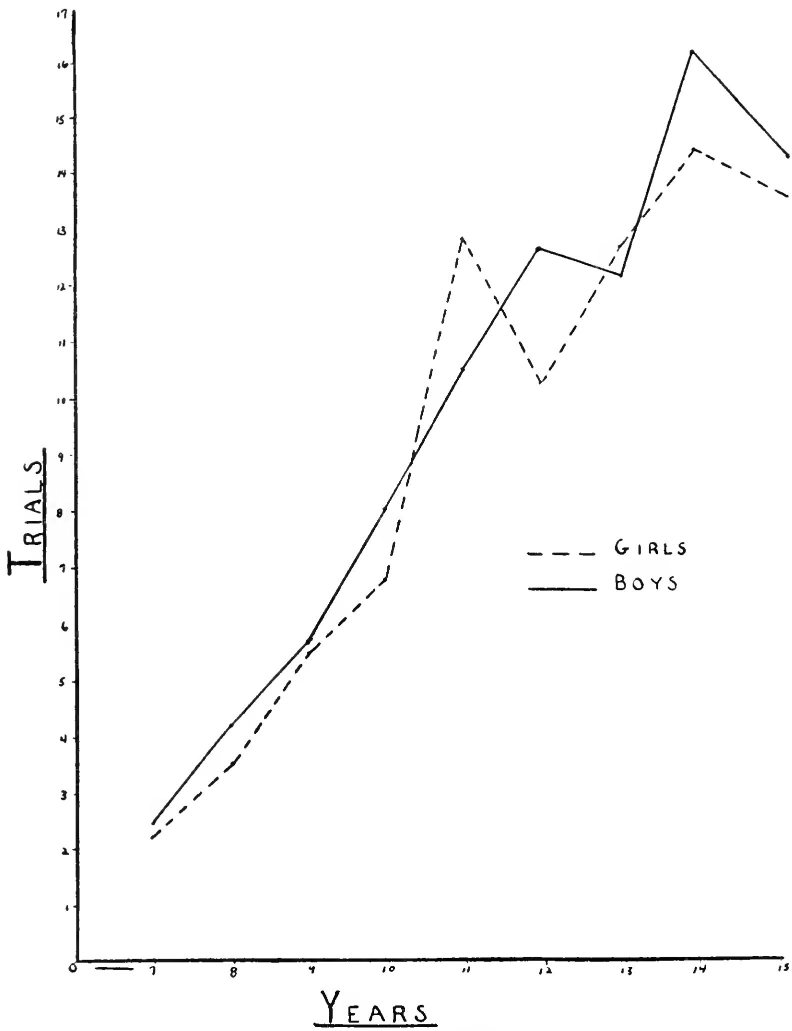

FIG. V. Speed of Formation of a C–R with Words as the Conditioning Stimuli (incidental association) in Groups of Children 7–15 Years of Age.

as already observed by Iliynsky (20), who reports that 70% of children change their word C–Rs in the presence of others.

88. Osipova (64) investigated experimental unconditioning of C–Rs with words as the conditioning stimuli in fifty 9–16-year-old children of different physical and mental states: normal, anemic, neurotic, blind, deaf-mute, and imbecile. The reaction which the children had to perform upon the experimenter's signal was the moving of their forearms along an arc in a special apparatus permitting the ready recording of the extent and character of the movements. All children are reported to have formed the C–R, or association, very readily, in 4–5 trials, but, unlike other C–Rs, no experimental unconditioning could be obtained except in a few children, despite hundreds of trials of administering the conditioned auditory and visual stimuli without the experimenter's "go." The magnitude and character of the response, as well as the general behavior of the children during the unconditioning experiments, are said to have corresponded closely to their particular states: the normal children giving regular responses and behaving quietly; the neurotics varying their responses widely with accompanying restless behavior; the anemic yawning, getting drowsy, and falling asleep; and the imbeciles greatly retarding their reactions. Osipova (64) also reports that 51 blind children, 9–18 years of age, only four of whom could establish, in 40 trials, a C–R to shock with an electric bell of 826 d.v. as the conditioned stimulus, readily formed the C–R in 4–18 trials[13] when the command "raise your finger" was substituted for the shock.

89. Dernova-Yarmolenko (14) compared the formation of an incidental association in 30 girls and 21 boys to so-called active and passive reactions. In the former, the conditioned stimuli—auditory, visual, or tactile—preceded the experimenter's command to the child to move his forearm along an arc of a special apparatus, while in the latter, the movement following the conditioned stimuli was guided by the experimenter. Altogether, 86 experiments were made with "active," and 99 with "passive" movements, and the results show a definitely greater effectiveness of the active reactions, in which associations were formed in 75 cases, while with the passive reactions only 7 associations were successfully formed.

90. *Experiments on Infants under One Year.* Denisova and Figurin (13) investigated the earliest appearances of natural and laboratory food C–Rs in 11 infants less than three months old. In all but one infant the experiments were begun 10–23 days after birth, the conditioned stimuli—the sound of a hidden bell, the flash

[13] Mean and S.D., computed by reviewer, equal 6.745 and 3.093 respectively.

of a red lamp in a darkened room, or both—being applied regularly each time the infants were fed for 45 seconds, 15 before and 30 after the feedings. In the remaining child, the experiment was begun 58 days after birth, the conditioned stimulus was the sound of a metronome of 72 beats per minute during the entire feeding time, one-half to two minutes. The experiments on natural C–Rs consisted in all infants of ascertaining the earliest food-seeking movements to originally inadequate stimuli.

91. The results are presented in Table XXXI, from which it

TABLE XXXI

NATURAL AND LABORATORY FOOD-SEEKING C–Rs IN 11 INFANTS LESS THAN 3 MONTHS OLD

Infants' initials	*Age at first appearance of natural C–R (holding in feeding position)*	*Experiments on laboratory C–Rs*			
		Age at beginning of experiment	*Age at appearance of C–R*	*Trials before appearance of C–R*	*Kind of conditioned stimulus*
T. B.	25 days	10 days	33 days	132	Bell
Z. B.	23 "	18 "	49 "	180	Bell
O. M.	24 "	19 "	56 "	213	Bell
O. L.	24 "	17 "	77 "	350	Lamp
V. S.	24 "	17 "	63 "	302	Lamp
N. G.	24 "	23 "	56 "	198	Lamp
M. K.	27 "	18 "	46 "	145	Bell & Lamp
V. I.	27 "	17 "	43 "	150	Bell & Lamp
V. A.	22 "	17 "	44 "	174	Bell & Lamp
A. M.	21 "	not reported			
A. C.	not reported	54 days	62 days	48	Metronome

may be seen that, in these infants, the natural C–Rs first appeared at 23–27 days after birth and laboratory C–Rs at 33–63 days. It would also seem from the table that auditory C–Rs are formed earlier than visual and that the great number of trials required for the formation of the C–Rs was largely because of immaturation; the greater effectiveness of the auditory stimuli is also partly corroborated by the experimenters' report that, in the three children

who formed the C–R to a compound visual and auditory stimulus, the visual component was ineffective when tested alone. Of course the small number of cases and the fact that the conditioned stimuli were not equated make the two last findings far from conclusive. It may also be added that the odor of milk, sight of breast, mother's voice were—unlike holding the infants in feeding position—ineffective at the particular ages tested as natural conditioned stimuli.

92. In another, more extensive experiment (16) Figurin and Denisova investigated the simple, differential, and negative conditioning, as well as experimental unconditioning in six infants. The experiments were begun four to seven and one-half months after birth and consisted of first forming simple food-seeking C–Rs in the children to the sight of nursing bottles set in hollow cubes of certain sizes and colors. When, after 4–5 days of experimentation with the younger and considerably less with the older children, the simple C–Rs to the nursing bottles were well established, the infants were given empty bottles set in cubes of other colors or sizes, or set in other geometrical forms, the empty and full nursing bottles being alternately presented 15–20 times in the course of 10–15 minutes. Negative C–Rs were formed by presenting the regular nursing bottles empty when they followed the ringing of an electric bell, while experimental unconditioning was performed by showing, but not giving, the full nursing bottles to the infants. The main results are presented in Table XXXII, from which it may be seen that the infants apparently first began to differentiate between the visual stimuli at seven months.

93. Other results not contained in the table are: the formation, in two infants aged 12–13 months, of negative C–Rs to the sight of the nursing bottle preceded by the sound of an electric bell; the ready experimental unconditioning of the C–Rs and easy formation of positive C–Rs even to the bottles previously made negative by differentiation. Another very interesting point brought out by the experiment is that, contrary to the usual reports of similar experiments on animals, the infants' responses to the negative stimuli, or empty bottles, were not merely indifferent. Instead, the infants displayed toward the negative stimuli, or bottles, definite vocimotor avoiding reactions, which often followed incipient approaching reactions—all of which causes the experimenters to doubt the existence of "internal inhibition" in these processes. The reviewer congratulates the experimenters on this schism from a fundamen-

TABLE XXXII

FORMATION OF DIFFERENTIAL FOOD-SEEKING C–RS TO VISUAL STIMULI IN SIX INFANTS

Infants' initials	*Age at which experiment with simple C–R began*	*Age at which experiment with differential C–R began*	*Age at which differential C–R first appeared*	*Experimental periods before appearance of differential C–R*	*Trials with empty bottles before differential C–R first appeared*	*Color of cube container for nursing bottle*	*Color and geometrical form of containers for empty bottles*
K. N.	120 days	138 days	210 days	20	192	Yellow	Blue cube
K. V.	158 "	172 "	216 "	17	352	Green	Red, yellow, blue, and black cubes; green sphere, cylinder and cone; green but smaller cube
K. A.	287 "	187 "	210 "	7	21	Blue	Yellow cube
C. N.	210 "	217 "	234 "	4	60	White	Blue, sky-blue, yellow, and green cubes
L. O.	210 "	253 "	273 "	9	98	Yellow	Blue cube
M. O.	225 "	302 "	310 "	4	60	Blue	Yellow cube

talist doctrine and earnestly wishes that more Russian experimenters on the C–R join this movement.

94. Levikova and Nevymakova (54) made a careful study of early simple and differential auditory conditioning to food in five infants with the sounds of B^4 on an organ pipe as the positive conditioned stimulus and the sounds of an electric bell and of B^5 on the same organ pipe as the stimuli to be differentiated. The experiments were begun 14–17 days after birth in four infants, and 86 days in the fifth infant, and were conducted once every day or every other day, the infants being blindfolded throughout the experimental periods. The experimental feedings, or giving the bottle, a few of which were made each experimental period, lasted only 20 seconds, and all responses were recorded kymographically. The results are presented in Tables XXXIII and XXXIV, from

TABLE XXXIII

FORMATION OF SIMPLE C–RS TO THE SOUND OF B^4 ON AN ORGAN PIPE IN FIVE INFANTS LESS THAN THREE MONTHS OLD

Infants' initials	*Age at which experiment began*	*Age at which C–R was first formed*	*Age at which C–R became stable*	*Trials before C–R was first formed*	*Trials before C–R became stable*
G.	16 days	73 days	77 days	126	134
V.	15 "	63 "	66 "	126	131
An.	14 "	65 "	79 "	91	110
Al.	17 "	65 "	110 " *	48	96
T.	86 "	92 "	96 "	42	51

* Child ill, and experiment discontinued for some time.

TABLE XXXIV

FORMATION OF A DIFFERENTIAL AUDITORY C–R IN FOUR INFANTS (POSITIVE CONDITIONED STIMULUS B^4 ON AN ORGAN PIPE)

Infants' initials	*Age at which differential C–R was formed*		*Trials with negative stimulus before formation of differential C–R*	
	Differential stimulus, bell	*Differential stimulus, B^5**	*Differential stimulus, bell*	*Differential stimulus, B^5*
G.	122	143	4	9
V.	120	134	14	8
An.	120	135	10	12
Al.	110	120	1	8

* Attempts to form a differential C–R to E^5, tried before the experiments with the bell, were unsuccessful.

which it may be seen that the infants formed their earliest simple auditory C–Rs 13–73 days after birth, and their differential C–Rs at 110–122 days. It should also be noted that, just as in the experiments of Figurin and Denisova, the infants, as a rule, reacted to the negative differential stimuli, not indifferently, but by definite voci-motor avoiding responses.

CHAPTER V

Individual Experiments in Conditioning

95. These experiments had not been performed in especially equipped laboratories and often lacked the most elementary control. With one notable exception, the experiment of Mateer, they were conducted upon very few subjects, and as a rule were very limited in their scope as studies of both the conditioning processes themselves and the relation of conditioning to other phenomena; they, however, yielded very interesting results and suggestive possibilities. For convenience of presentation they are reviewed as: C–Rs with food as the conditioning stimulus; C–Rs with nocuous conditioning stimuli; other C–Rs (Babinski, Patellar, PGR, Laughter).

96. *C–Rs with Food as the Conditioning Stimulus.* The Work of Mateer. Mateer (57) investigated motor conditioning of food in a large number of children: 50 normal children, 12–89 months of age; a group of subnormal children with C.A.'s of 57–93, M.A.'s of 49–86 months, and I.Q.'s of 58–92; another subnormal group with C.A.'s of 34–73, M.A.'s of 12–30 months, and I.Q.'s of 22–71; two normal but maladjusted children, 75 and 85 months of age; and one superior child with a C.A. of 65 and an M.A. of 88 months. With the exception of the work with the lower subnormal group and with the superior child, which constituted the preliminary experiment, the conditioning consisted of putting a bandage over the child's eyes for 20 seconds, feeding it with chocolate on the 11th second, removing the bandage at the end of the 20 seconds, and taking kymographic records of the child's throat movements by placing a Marey tambour over his thyroid cartilage. The intervals between successive trials were invariably three minutes and each experiment did not last as a rule for more than half an hour. Four phases of conditioning were investigated in the main experiment: learning, or formation of the C–R; unlearning, or experimental unconditioning; memorial functioning, or retention of the C–R; relearning, or reconditioning. The associations of the bandage with the food were first continued until the children showed two successive food responses to the bandage alone. The experiment was then discontinued for 24 hours and the retention of the C–R tested; if the C–R was not retained it was reinforced until it was restored for two successive trials. The retained or restored C–R was now experimentally unconditioned, by applying the bandage

TABLE XXXV

CONDITIONING, RETENTION OF CONDITIONING, EXPERIMENTAL UNCONDITIONING, AND RECONDITIONING OF MOTOR C–RS TO FOOD IN 67 CHILDREN

Groups studied	*Trials before appearance of C–R*				*Trials for retention of C–R after 24 hours*	*Trials for experimental unconditioning*				*Trials for reconditioning*
	Range	*mean*	*S.D.*	*V*		*Range*	*mean*	*S.D.*	*V*	
50 normal children (Age = 12–89 months)	3–9	5.2	1.97	37.88	2–7* (38 = 2; 9 = 3; 1 = 4; 1 = 5; 1 = 7)	3–12	7.27	1.153	15.722	2–4* (38 = 2; 2 = 3; 1 = 4)
						(For only 41 children)				
7 subnormal children (C.A. = 57–93) (M.A. = 49–86) (I.Q. = 58–92)	3–13	6.43	3.014	46.87	2–7	8–16	12.29	3.04	24.736	2
7 lower subnormal children (C.A. = 34–73) (M.A. = 12–30) (I.Q. = 22–71)	5–18	10.57	4.341	41.07	......	......	......	......	......	......
32 normal children (Age = 48–49 months)	3–7	4.41	1.628	36.92	......	3–12	6.91	1.19	17.25	......
5 normal children (Age = 12–29 months)	7–9	8.00	0.638	7.98	......	......	......	......	......	......
2 normal but maladjusted children (Age = 75 and 85 months)	4–7	......	......	......	2, 2	7, 21	......	......	......	2, 2
One superior child (C.A. = 65; M.A. = 88)	5	Formation of differential tactile C–R unsuccessful even after 5 days of experimentation			......	6	......	......	......	......

* The minimum in experimenter's procedure.

alone, until the C–R disappeared for two successive trials. Finally, the bandage was again combined with feeding until the C–R reappeared for two trials. In the preliminary experiment both the blindfolding and a tactile stimulation served as the conditioning stimulus, and in the group of the lower subnormal children, whose responses were not recorded kymographically, only conditioning and retention were studied, while simple conditioning, retention, and differential tactile conditioning were investigated in the superior child. The quantitative results on the four phases of conditioning in the various groups are presented in Table XXXV, some of the entries of which have been taken directly from and some computed from Mateer's tables.

97. The normal children were also given in the intervals between trials a number of physical and mental tests, and intercorrelations between the various scores of the tests and of the four phases of conditioning were computed by the experimenter. Little, if any, importance can, however, be attached to the correlations with retention and reconditioning since 76% of the children retained the C–R perfectly and 38 of the 41 children (learning had to be discontinued with nine children) required only the minimum of two trials for reconditioning. The correlations with conditioning and experimental unconditioning are, however, of considerable interest and the more significant ones are given in Table XXXVI; the correlations between conditioning and I.Q., M.A., C.A., and

TABLE XXXVI

Correlations between Conditioning, Experimental Unconditioning, C.A., M.A., and Scores on Goddard's Adaptation Board in 50 Normal Children, and between Conditioning I.Q., C.A., and M.A. in 14 Subnormal Children

	Conditioning	*Unconditioning*	*C. A.*	*M.A.*	*Goddard*
Conditioning	....	0.450	0.571	0.588	0.366
Experimental unconditioning	....	....	0.316	0.251	0.280
C.A.	....	....	....	0.949	0.708
M.A.	....	....	....	....	0.716
Goddard's adaptation board	....	....	....	....	....
	14 subnormal children				
Conditioning and I.Q.	0.258				
Conditioning and M.A.	0.323				
Conditioning and C.A.	0.377				
C.A. and M.A.	0.721				
C.A. and I.Q.	0.438				

between C.A., M.A. and I.Q.—computed by the reviewer—in the 14 subnormal children are also given in this table.

98. The reviewer has also computed the regression equations in their special form of experimental unconditioning on conditioning, M.A., and G.A.B., on conditioning, C.A., and G.A.B., on M.A. and G.A.B., and on C.A. and G.A.B., and of conditioning on M.A. and G.A.B., and on C.A. and G.A.B., as well as their respective multiple correlations. The equations are:

1. Experimental Unconditioning = 0.457 Conditioning − 0.151 M.A. + 0.220 G.A.B.
2. Experimental Unconditioning = 0.396 Conditioning + 0.078 C.A. + 0.145 G.A.B.
3. Experimental Unconditioning = 0.104 M.A. + 0.205 G.A.B.
4. Experimental Unconditioning = 0.238 C.A. + 0.112 G.A.B.
5. Conditioning = 0.669 M.A. + 0.111 G.A.B.
6. Conditioning = 0.620 C.A. + 0.076 G.A.B.

The multiple correlations are:

1. R experimental unconditioning (Conditioning, M.A., G.A.B.) = 0.464
2. R experimental unconditioning (Conditioning, C.A., G.A.B.) = 0.460
3. R experimental unconditioning (M.A., G.A.B.) = 0.289
4. R experimental unconditioning (C.A., G.A.B.) = 0.326
5. R conditioning (M.A., G.A.B.) = 0.648
6. R conditioning (C.A., G.A.B.) = 0.574

99. From Tables XXXV and XXXVI and from the regression equations and multiple correlations it is seen that in a normal group of 50 children the variabilities of the speeds of both conditioning and experimental unconditioning are rather small, and that there is a fair positive correlation between the speeds of conditioning and unconditioning, between the speed of conditioning and scores on verbal and performance mental tests, and between speed of conditioning and age, with smaller positive correlations of age and scores on these tests with speed of unconditioning. The smaller correlation of speed of experimental unconditioning with ontogeny is in line with results indicating similar phylogenetic relationships, a tentative explanation of which is offered by the reviewer elsewhere (Psychol. Bul., April, 1933). Speed of conditioning correlates positively, furthermore, not only with absolute scores on verbal and performance tests, or M.A.'s, but also with I.Q.'s, or—which is the same—correlates negatively with C.A. if

M.A. is constant, as may be seen from the comparison of speeds of conditioning of normal and subnormal groups of the same M.A.'s as well as from the higher correlation of speed of conditioning with M.A. than with C.A. These correlations, derived as they are from a large number of cases, appear to be significant despite the obvious primitiveness of the Mateer conditioning technique and laboratory and the possibility of secondary cues.

100. An interesting experiment on the conditioning of the feeding reactions of 10 infants, less than 10 days of age, was performed by Marquis (56). The conditioned stimulus was a buzzer which was sounded each time—five seconds before and five seconds after—the infants were given the nursing bottles, the infants being fed 6 times a day and the bottles being removed 2–5 times during each feeding. Besides the experimenter's observations, the infants' general bodily movements were recorded by means of a special stabilometer consisting of a platform mounted on roller bearings and their sucking reactions by means of a capsule placed under the chin. In the last two days of the experiment, control stimuli—a flashlight and the striking of a hammer on a tin can—were also administered to the experimental infants, while four infants, during whose feeding periods the buzzer was sounded but not followed by food, served throughout the experiment as a control group. The results are presented in Table XXXVII, which has been compiled from the experimenter's data, and in Figure VI, which is reproduced from the experimenter's report. As it may be seen from the table and the figure there appears to be definite evidence for the conditioning of seven infants, although it is to be regretted that the experimenter does not present any kymographic records nor more detailed data for statistical treatments.

101. Bogen (7, 8) established a gastric C–R to the sound of a trumpet and investigated conditioning and natural conditioned gastric secretion in a three-and-a-half year old child who suffered from aesophagostenosis and had to be fed through a gastric fistula. The child was laid down prone upon his stomach and his gastric secretions taken—by means of a tube fixed over the fisutla—in 15-minute experimental periods, each experimental period beginning only after the initial secretion had ceased. The results are presented in Table XXXVIII, which is merely the experimenter's table, and from which both the gastric conditioning and the increase in conditioning secretion by the simultaneous application of the conditioned stimulus are rather apparent. The experimenter

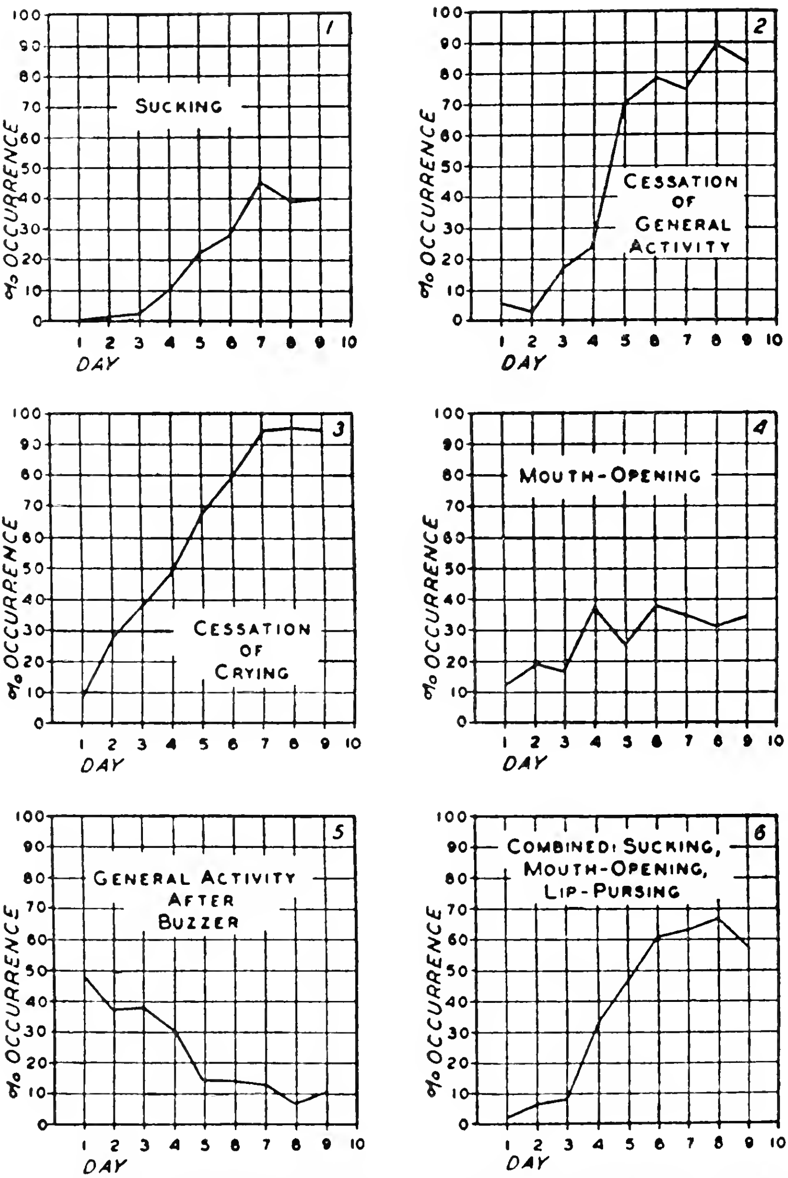

FIG. VI. Conditioned Responses in Seven Newborn Infants (from Marquis, D. P. Can Conditioned Responses be Established in the Newborn Infant? *Ped. Sem.*, 1931, 39, 487).

also reports that anger and an electric shock stopped the gastric

TABLE XXXVIII

CONDITIONING AND CONDITIONED GASTRIC SECRETION IN 15-MINUTE PERIODS IN A THREE AND A HALF YEAR-OLD CHILD

Experimental condition	*Number of experimental periods*	*Average amount of secretion (in ccs.)*	*Latency in seconds*	*Experimental periods with no secretion*
Sham feeding (meat in mouth)	5	10.40	4.00	0
Showing meat	2	4.85	6.00	0
Talking of meat	5	2.82	4.90	0
Trumpet plus sham feeding	35	12.20	4.57	0
Trumpet plus showing meat	5	6.67	4.75	2
Trumpet plus talking of meat	7	4.50	4.00	3
Trumpet alone	10	4.64	5.20	3

secretion. Gastric secretions to the sight and smell of milk in a nine-month-old child were also noted by Nothman (60) through probing the stomach; he further found the secretion to be produced by mere sucking of an empty bottle in two newly-born infants who had not yet been fed.

102. Chura (10) attempted the formation of a glycometabolic C–R by combining the sounding of a bell with the injection of insulin in one diabetic seven-year-old child and with the administration of glucose in another child, 13 years and 9 months of age, afflicted with Gaucher's disease. In the first case the child's urine would become sugar-free for a long time only after 3 injections of 6 units of insulin, but after 21 daily combinations of the injections with the sounding of the bell a number of sugar-free days resulted when the conditioned stimulus was by error combined with only one-half of the injection. In the other child, with whom from October 17th to December 22nd daily combinations—with a few days of rest—of the sounding of a bell with the administration of 1.5 gms. of dissolved glucose per kg. of weight were made, no traces of conditioning—as evidenced by the sugar-blood curves—were noted in three tests of sounding the bell with the

administration of unsweetened tea, performed on December 13th and 22nd.

103. *C–Rs with Nocuous Conditioning Stimuli.* Slutskaya (74) investigated the comparative conditioning dominance of food and of nocuous stimuli by attempting to change nocuous into food C–Rs in 5 normal children, 11–21 months of age, two 5-year old idiots, and one 11-year old imbecile. The experiment consisted of first pricking the children with a needle and forming a voci-motor avoiding C–R to the sight of the needle—in one case to the sound of a bell—and then following the pricking immediately by feeding; no special apparatus and control have been used in the experiment and no equating or even uniformity of the conditioning stimuli are reported. The results are presented in Table XXXIX, from which it may be seen that, except in 3 cases, the avoiding nocuous C–Rs first weakened, then disappeared, and finally changed into characteristic approaching food C–Rs.

104. Watson (78, 79) studied conditioning in an 11-month-old child by combining the striking of a steel bar with the sight of furry animals— rat, rabbit, and dog. Two combinations of the auditory stimulus with the sight of a rat seem to have brought about some change—tested seven days later—in the overt behavior of the child toward the rat, while three more joint stimulations on the tested day produced a so-called "fear" response of puckering the lips, whimpering, and withdrawing the body, which, after two additional stimulations, carried over ten days. When now the striking of the bar was again combined one time each with the sight of the rat, a rabbit, and a dog, the child showed negative attitudes, after an interval of 31 days, toward a Santa Claus mask, fur-coat, rat, rabbit, and dog, but played with blocks. Jones (30) described with some detail the elimination of an apparently natural C–R of "fear" to the sight of a rabbit in a child 10 years and 2 months old by introducing the animal first while the child was playing with three children who had no similar "fear," and then while the child was being fed. The elimination experiment lasted for 45 sessions—first twice and then once a day—and the child's reactions are reported to have changed from "fear" paroxysms in the presence of the rabbit anywhere in the room to the child's letting the rabbit nibble his fingers; the gradual process of the elimination was twice impeded, once by a dog jumping at the child and another time when the rabbit slightly scratched the child, as well as probably by the child's illness for 11 weeks during the course of the experiment.[14]

[14] Jones' other results (29, 31) on the elimination of "fear" responses in children are too descriptive and fragmentary to be reviewed here.

TABLE XXXIX

Changing Nocuous C–R into Food C–Rs in Eight Children

Age of child	*Clinical diagnosis*	*Trials before first appearance of nocuous C–R*	*Trials before beginning of feeding*	*Number of feedings before nocuous C–R*			*Remarks*
				weakened	*disappeared*	*changed into food C–R*	
11 months	Normal	18 (Bell = conditioned stimulus)	43	2	9	14	Child opens mouth to sound of bell.
13 months	Normal	2	......	9	12	......	
14.5 months	Normal	1	9	......	16	22	Swallowing movements to sight of needle
18 months	Normal	1	11	......	......	......	28 feedings but no effect
21 months	Normal	2	......	......	......	......	19 feedings; no weakening of nocuous C–R
5 years	Idiot	1	8	16	43	43	Nocuous C–R unconditioned in 5 trials
5 years	Hydrocephalic	1	......	......	......	......	Nocuous C–R slightly weakened by 59 feedings
11 years	Imbecile	1	18	8	......	19	Change unstable; avoiding responses to sight of needle occasionally

105. The conditioning, generalization, experimental unconditioning, and reconditioning of the withdrawal response from shock to an electric bell in a 15-month-old child is described by Jones (28). First, in order to negatively adapt the child to the auditory stimulus, the bell was repeatedly sounded alone 10 times, each repetition lasting two seconds, and the first disappearance of any overt "investigatory" reaction occurring after four repetitions. The conditioning was then begun by applying an electric shock at the end of the two seconds and combining the bell and shock for three additional seconds, with intervals of 15 seconds between successive combinations; the child's responses were not recorded kymographically but were noted by two observers concealed behind a one-way vision screen. The C–R first appeared after three trials and did not disappear until after nine non-reinforced trials with the bell and two with a buzzer, but could not be elicited by a hand-bell of different timbre and frequency. The C–R was then restored by five reinforcements and afterwards given in response to the bell alone for 18 additional trials, while the next day the C–R appeared without reinforcement upon the second trial and did not disappear until after six more trials with the bell and one with the buzzer, although it again failed to appear when the hand-bell was sounded, as well as when the bell was given together with food; 72 hours later the experimentally unconditioned C–R reappeared spontaneously.

106. Marinesco (55) established a C–R to shock—applied in one experiment to the hand and in the other to the foot—in a nine-year-old child who had become functionally mute for two months as the result of an automobile accident that, however, caused no apparent physical injury. The conditioned stimulus was a metronome of 60 beats per minute and the C–R first appeared after 12 and 27 combined applications of the shock to the hand and foot respectively, while it was experimentally unconditioned after respectively sounding the metronome alone 26 and 22 times. A withdrawal C–R in a four-month-old baby—thought to be deaf by three physicians—to the sound of a small dinner bell after 12–15 combinations of the bell with scratching the infant's sole with a pin is also reported by Aldrich (1).

107. *Other C–Rs.* Patellar. Goldenfoun (18) experimented with patellar and defensive C–Rs in four subnormal children. The ages of three children were 8, 8 and one-half, and 13 and one-half years, with respective M.A.'s of four and one-half, five, and two

years, while the fourth child, 9 years old, was a total idiot who could neither talk nor eat unaided. The conditioned stimulus was in all cases the sounding of the note *d* on a tuning fork, while in the first, second, and fourth children the conditioning stimulus was a blow on the patella by a percussion hammer to which the first two children responded with normal knee-jerks but the fourth with violent wide-spread motor and vocal reactions; in the third child, who showed no normal patellar response, the conditioning of the child's defensive reactions to pricking the knee with a blunt point was investigated. The conditioned preceded the conditioning stimuli by 1–2 seconds, but the number of trials in an experimental

TABLE XL

Patellar and Defense C–Rs in Four Subnormal Children

Age of child	8 years	$8\frac{1}{2}$ years	$13\frac{1}{2}$ years	9 years
M.A.	4.5	5.0	2.0	......
Total number of experimental days	23	6	18	5
Number of combinations of conditioned and conditioning stimuli	603	490	394	68
Trials before appearance of C–R				
Conditioned stimulus plus stimulation of opposite knee	135	60	45	......
Conditioned stimulus alone	235	180	58	2
Number of times C–R appeared	100	66	86	19*
Number of times C–R failed to appear	54	19	121	......
Doubtful	10	4	34	......

* C–R present after 11 days of no experimentation.

session and the intervals between successive trials varied very widely; indeed, in certain sessions 50–70 combinations were made in three minutes, factors of fatigue and distributed practice thus being completely ignored. As the conditioning in the first three children was rather slow, striking or pricking the unstimulated knee was introduced as an auxiliary stimulus in the first part of the training series; the children were blindfolded, but their responses were not recorded kymographically, being observed by the experimenter who was apparently in the same room with the subjects.

108. The results are presented in Table XL, the entries of which have been computed from the experimenter's detailed re-

port, and from which the conditioning is rather apparent. The C–Rs are, however, reported to have been very generalized, being evoked even more readily by tactile stimuli, such as a blow on the head or shoulder or stimulation of the stylo-radial, that had not previously been combined with conditioning stimuli. On the other hand, the experimenter's conclusion that "the speed of formation of the C–R is inversely proportional to intelligence" is simply not warranted by the presented data, since the first two children hardly differed in intelligence, while the response of the fourth child and both the stimulus and response of the third child differed from those of the first two children.

109. Babinski Reflex. Resek (66) reports a conditioned Babinski C–R in a 5-year-old child who suffered from infantile paralysis and had heightened patellar and Babinski reflexes. After a number of trials with stroking the planta either with the handle of a percussion hammer or with the cathode of a faradic current, a distinct dorsal flexion of the toe was observed when the experimenter just brought the electrode near the toes. The C–R became unconditioned after 3–4 non-reinforced trials and would not be evoked by auditory stimuli.

110. Psychogalvanic Response. Jones (27) first reported the formation of conditioned PGR's in three 3–9-month-old infants after 4–14 combinations of auditory, visual or tactile stimuli with a very mild shock, the stimuli having been previously made indifferent to the PGR by negative adaptation. As spontaneous recoveries from the negative adaptation could, however, at times be mistaken for C–Rs, Jones' further extensive study of conditioned PGR in a seven-month-old infant was made with two stimuli that had been originally found to be indifferent to the PGR: the sounding of a small armature against an induction coil out of the child's sight and the intermittent flashing of an electric bulb three feet in front of the child's eyes. The conditioned stimuli preceded the shock—over which a control was kept by an adult in series—by 10 seconds and the two stimuli continued for 10 additional seconds; the PGR to a buzzer, a control for the effect of maturation, was also from time to time tested.

111. The C–R to the sounding of the armature first appeared after six trials and was altogether elicited on that experimental day for 19 out of 35 trials with an average magnitude of 7.4 mms., while the frequency of the PGR to the shock was 71%. In the next four days, the conditioning procedure of which consisted of sound-

ing the armature first 8 times without and then 7 times with shock, the average frequencies of the C–R for successive series of three trials were 75, 8, 6, 58, and 42, with respective average magnitudes of 15, 5, 0.4, 0.5 and 2.9 mms., while the frequencies of the PGR to the shock were 100 for the first trial, and 83 and 73 for the two successive series, with respective magnitudes of 10.3, 19.8, and 10.3. Beginning with the sixth day the conditioned stimulus was no longer reinforced, but still maximum responses were obtained in the first trials the 13th, 14th, and 20th days from the beginning of the experimentation, and 7–10 non-reinforced applications were required before the disappearance of the conditioned PGR on some one experimental day. The results of the further trials with sounding the armature as the conditioned stimulus, as well as with the buzzer as a control, are presented in Table XLI, taken directly from Jones' table and data.

TABLE XLI

MAGNITUDE OF CONDITIONED PGR'S TO SOUND OF ARMATURE IN A 7-MONTH-OLD INFANT, 26–49 DAYS AFTER LAST REINFORCEMENT WITH CONDITIONING STIMULUS

Days since last reinforcement	*Average magnitude in mms for first three trials*	*Average frequency*	*Control results with buzzer*
26	30.3	78%	(PGR before experiment was 7.1 mms.)
27	14.6		
28	29.7		Average 5.4 mms.
29	5.0		
31	6.6		
32	4.4		
42	13.3	39%	" 5.0 mms.
43	13.3		
44	0.0		
45	4.6		
48	0.0		
49	2.5		

112. With the intermittent flashing of the electric bulb as the conditioned stimulus the combinations with shock were distributed

over a number of days: 20 combinations in 1–7 days, 5 on the 14th, and 10 on the 22nd day from the beginning of experimentation. The C–R first appeared on the 13th day and a number of positive responses were obtained on the 15th, 20th, but not 21st day; another series of C–Rs were given the 23rd, 27th, 31st, 32nd, but none on the 33rd, 34th, 36th, 37th day, although on the 38th day the successive magnitudes were: 0, 6, 1, 0, 17, 10, 0, 1 mm. The vagaries of the PGR notwithstanding, the Jones results on the lastingness of the C–R are rather interesting, being comparable to the results obtained from the much more extensive experiment of Mikhailoff on cephalopods, presented elsewhere (*Psychol. Bull.,* April, 1933).

TABLE XLII

Conditioning of Laughter Response in an Eight-Year-Old Child with an M.A. of Four and One-Half Years

Stimulus	*Nature and Frequency of Response*			
	Laughter	*Smiling, reddening of face, general contraction of facial muscles*	*Defence reactions*	*No overt reaction*
Metronome plus tickling of axilla	117	1	5	5
Metronome alone	32	32	4	24

113. Laughter. Pacaud (65) studied laughter C–Rs in a subnormal 8-year-old child with an M.A. of four and one-half years by sounding a metronome of 138 beats per minute one second before tickling the child's axilla, the intervals between successive trials being 2–3 minutes. The child was blindfolded in part of the experiment, but the experimenter was not isolated from the subject's room, and apparently no other means for ruling out secondary cues were used. The C–R appeared after the first trial and the experiment was conducted for 10 days.

114. The main results are presented in Table LXII, from which the conditioning of the laughter response may be seen. The C–R was apparently very generalized: when a tuning fork, to which the child previously had a patellar C–R, was sounded on the 7th day of the laughter conditioning, 6 laughter responses and only 4 knee-jerks were elicited; banging the piano keyboard on the same day also produced laughter, while sounding the tuning fork together with the metronome, as well as drumming with the fingers, gave both C–Rs.

CHAPTER VI

Summary and Conclusions

Summary

115. The comparable results on speeds of formation, magnitudes, and latencies of the simple simultaneous C–R, as well as the correlations, are summarized in Tables XLIII and XLIV. For the many other less comparable results on the different phases of conditioning and on the relations between conditioning and other organismic activities—which cannot be well represented on a uniform scale—the reader is referred to the conclusions and to the text of the review.

Conclusions

116. In this section are brought together all the significant facts of the conditioning of children, the evidence of which has been presented in the text and tables of the review. The evidence, or the degree of establishment, of these facts, or conclusions, varies widely from results obtained from experiments in well-controlled laboratories and based upon statistically reliable measures of a large number of cases, where secondary cues and chance variations may reasonably be considered to be ruled out, to experimental findings and techniques rather crude but not proven unreliable, while in some cases are included merely the experimenters' statements of their results provided these results are not contradicted by or incompatible with other existing knowledge of conditioning. For convenience, the conclusions are presented severally under a number of headings and sub-headings, while to facilitate the reader's finding and evaluating the reliability of the evidence for the conclusion, each conclusion is followed by two sets of numerals, the first being the paragraph numbers of the text in which the evidence is presented (in some cases table numbers—T.—, Figure numbers —Fg.—, and in a few cases footnote numbers—Ft.—are given) and the second the reviewer's rating of the evidence on a scale of three, with the higher number standing for the higher rating.

General Conclusions about Formation of C–Rs.

1. Simple positive C–Rs, in which originally inadequate stimuli for some response have become adequate by virtue of their associa-

TABLE XLIII

COMPARATIVE SPEEDS OF FORMATION AND MAGNITUDES OF SIMPLE SIMULTANEOUS C–Rs IN CHILDREN

Type of C–R	*Experimenter*	*Number of cases*	*Age range*	*Speed of Formation (trials)*				*Magnitude*			
				Range	*Mean*	*S.D.*	*V*	*Range*	*Mean*	*S.D.*	*V*
Shock	Osipova, Korotkin, Sinkievich, and others	205	7–19 years	1–90	10.03	11.84	118.05	......	......	......	......
Food Secretory	Chuchmarev	7	6th grade	2–20	10	5.155	51.55	25.5–64.5	46.929	11.16	23.783
								(Cubic mms. in 25 seconds)			
"	Krasnogorski's Laboratories	40	3–15 years	Experimental conditions and stimuli differ too widely for a summary statistical treatment.				1–14	4.215	2.866	67.99
								(Drops in 30 seconds; computed from 130 cases)			
Motor	Mateer	67	12–93 months	3–18	5.89	2.92	49.83	......	......	......	......
"	Krasnogorski's Laboratories	43	3–15 years	Experimental conditions and stimuli differ too widely for a summary statistical treatment.				1.2–5.0	3.021	0.889	29.427
								(Centimeters; computed from 90 cases)			
Grasping	Novikova, Korotkin, and Sinkievich	29	9–10 years	2–20	4.69	3.637	77.565	......	......	......	......
Verbal (Incidental Association)	Osipova and Oparina	145	7–18 years	2–35	9.38	3.61	38.49	......	......	......	......
Patellar	Goldenfoun	2	8, 8.5 years (M.A.'s = 4.5, 5)	180, 235	......	......	......	......	......	......	......
PGR	Jones	3	3–9 months	4–14	......	......	......	......	......	......	......
Laughter; and Voci-motor reactions to nocuous stimuli	Pacaud, Watson, Slutskaya, and Goldenfoun	11	11 months–11 years (M.A. not above 5	1–2	......	......	......	......	......	......	......

TABLE XLIV

CORRELATION BETWEEN VARIOUS PHASES OF CONDITIONING AND BETWEEN CONDITIONING AND OTHER TRAITS AND PERFORMANCES OF CHILDREN

Nature of correlation	*Experimenter*	*No. of cases*	*Coefficient of correlation and P.E.*
Speed of formation of a C–R to shock with age, 7–19 years, in a normal group	Osipova	142	– 0.358 ± 0.033
Speed of formation of a C–R to shock with age, 7–14 years, in a normal group	"	116	– 0.029 ± 0.0425
Speed of formation of a C–R to shock with age, 14–19 years, in a normal group	"	28 + 116	– 0.716 ± 0.0641 (Biserial r)
Speed of formation of a C–R to shock with age, 7–14 years, in a subnormal group	"	58	0.079 ± 0.06
Speed of formation of a C–R to food with age, 12–89 months, in a normal group	Mateer	50	0.571 ± 0.0643
Speed of formation of a C–R to food with age, 12–92 months, in a subnormal group	"	14	0.377 ± 0.156 (ρ)
Speed of formation of a C–R to food with age and I.Q. of children 12–92 months	"	14	R conditioning (C.A., I.Q.) = 0.404
Speed of formation of a C–R to food with age and Binet M.A. of children 12–92 months	"	14	R conditioning (C.A., M.A.) = 0.399
Speed of formation of a C–R to words (incidental association) with age, 7–16 years, in a normal group	Oparina	99	– 0.556 ± 0.0475
Speed of formation of a C–R to food with age, 12–89 months, in a normal group and per formances on the Goddard Adaptation Board	Mateer	50	Conditioning = 0.620 age + 0.076 Goddard Adaptation Board R conditioning (age, Goddard Board) = 0.574
Speed of formation of a C–R to shock with intelligence in children 8–14 years old	Osipova	56 + 58	– 0.540 ± 0.0789 (Biserial r)
Speed of formation of a C–R to food with intelligence (Binet M.A.) in children 12–89 months old	Mateer	50	0.588 ± 0.0624
Speed of formation of a C–R to food with intelligence and performances on Goddard Adaptation Board in children 12–89 months old	"	50	Conditioning = 0.669 M.A. + 0.111 G.A.B. R conditioning (M.A., G.A.B.) = 0.648

TABLE XLIV.—(*Continued*)

Type of correlation	*Experimenter*	*No. of cases*	*Coefficient of correlation and P.E.*
Speed of formation of a secretory C–R to food with school achievement in children of the 6th grade	Chuchmarev	7	0.893 ± 0.050 (ρ)
Speed of formation of a C–R to shock with deaf-mutism in children 11–18 years old	Osipova	89 + 64	$\chi^2 = 25.37$; P ∠ 0.01
Speed of formation of a C–R to shock with sex in children 7–19 years old	"	75 + 67	$\chi^2 = 5.154$; P = 0.025 (in favor of girls)
Speed of formation of a secretory C–R to food with its magnitude in children of the 6th grade	Chuchmarev	7	0.571 ± 0.174 (ρ)
Speed of formation of a simple and differential secretory C–R in children of the 6th grade	"	7	0.536 ± 0.185 (ρ)
Speed of formation of a differential secretory C–R with school achievement in children of the 6th grade	"	7	0.643 ± 0.150 (ρ)
Speed of experimental unconditioning with age in children 12–89 months old	Mateer	50	0.316 ± 0.0859
Speed of experimental unconditioning with intelligence in children 12–89 months old	"	50	0.251 ± 0.0894
Speed of experimental unconditioning with speed of conditioning, age, and performances on Goddard Adaptation Board in children 12–89 months old	"	50	Unconditioning=0.396 cond. + 0.078 C.A. + 0.145 G.A.B. R unconditioning (cond., C.A., G.A.B.) = 0.460
Speed of experimental unconditioning with speed of conditioning, M.A., and performances on Goddard Adaptation Board in children 12–89 months old	"	50	Unconditioning=0.457 cond. − 0.151 M.A. + 0.220 G.A.B. R conditioning (cond., M.A., G.A.B.) = 0.464
First appearance with stabilization of grasping C–R to food in children 9–10 years old	Novikova	9	0.190 ± 0.1956 (ρ)
First appearance of positive with first appearance of negative grasping C–Rs to food in children 9–10 years old	"	9	− 0.024 < P.E. (ρ)
Stabilization of positive with stabilization of negative grasping C–Rs to food in children 9–10 years old	"	9	− 0.125 ± 0.161 (ρ)

TABLE XLIV.—(*Continued*)

Type of correlation	*Experimenter*	*No. of cases*	*Coefficient of correlation and P.E.*
Magnitudes of conditioned with subsequent conditioning salivation in a child 10 years old	Wolowick	35	0.157± 0.111
Magnitudes of salivary with magnitudes of motor C–Rs in children 4–15 years old	Juschtschenko	83	0.105 ± 0.073
Magnitude with latency of salivary C–R in children 4–15 years old	"	83	– 0.539 ± 0.052
Magnitude with latency of motor C–R in children 4–15 years old	"	83	0.103 ± 0.073
Magnitude of salivary with latency of motor C–Rs in children 4–15 years old	"	83	0.053 ± 0.074
Magnitude of motor with latency of salivary C–R in children 4–15 years old	"	83	0.150 ± 0.072
Latencies of salivary with latencies of motor C–Rs in children 4–15 years old	"	83	– 0.201 ± 0.071
Magnitude with latency of grasping C–R to food in children 9–10 years old	Korotkin	18	0.139 ± 0.087
Magnitude with latency of withdrawing C–R to shock in children 9–10 years old	"	18	– 0.595 ± 0.053
Magnitudes of simple C–R at beginning and end of session with school achievement in children of the 6th grade	Chuchmarev	7	0.714 ± 0.124 0.081 ± 0.265 (ρ)
Percentage of magnitude of conditioned salivation — in terms of subsequent conditioning salivation—with school achievement of children in the 6th grade	"	7	0.678± 0.138 0.812 ± 0.086 (ρ)
Percentage of magnitude of experimentally unconditioned C–R in terms of the magnitude of the original C–R—with school achievement of children in the 6th grade	"	7	0.759 ± 0.107 (ρ)
Magnitude of conditioning salivation to food at beginning and end of session with school achievement of children in the 6th grade	"	7	0.786 ± 0.096 0.679 ± 0.137 (ρ)

tion with adequate stimuli, have been formed in children a few days of age (100: 3).

2. The following responses were conditioned in children: food—salivation (Krasnogorski's and Chuchmarev's Laboratories: 3), gastric secretion (101: 3), motor activities accompanying eating (Krasnogorski's and Bekhterev's Laboratories: 3; Mateer: 3), grasping some object to obtain food (Ivanov-Smolensky's Laboratory: 3); withdrawing from shock (Bekhterev's and Ivanov-Smolensky's Laboratories: 3), voci-motor responses to nocuous stimuli (103, 104, 107: 3); patellar (107–108: 2); Babinski (109: 1); PGR (110–111: 2); laughter (113–114: 3); verbal, or incidental association (Bekhterev's Laboratory: 3).

3. C–Rs have been formed to chains or successive series of different stimuli of the same or of different modalities, S_1 S_2 S_3 . . . S_n, by applying S_1 S_2 S_3 . . . S_n at short regular intervals and reinforcing the last stimulus with food (Krasnogorski's and Ivanov-Smolensky's Laboratories: 3). The longest chains reported are (a) 8 different stimuli of three different modalities and each stimulus lasting 30 seconds (25: 1); (b) 12 different stimuli of the same modality and the stimuli lasting one second each with intervals of one second between them (71: 1). After the formation of a C–R to some chain, an incomplete chain either produces a reduced C–R or fails to elicit the response at all (27, 29: 3).

4. C–Rs with triple chained responses, or when some stimulus S_1 comes to arouse C–R_1 + C–R_2 + C–R_3, have been formed by first establishing separately C–R_1, C–R_2, and C–R_3 to S_1, S_2, and S_3 following each other at regular short intervals (72: 1).

5. Negative C–Rs, or when a C–R to some stimulus S_1 is made to disappear whenever S_1 is applied simultaneously with or shortly after some stimulus S_2, have been formed in a large number of children (Krasnogorski's and Ivanov-Smolensky's Laboratories: 3).

6. C–Rs of higher order, or when a C–R is formed to S_2, S_3 . . . S_n by first forming a C–R to S_1 and then repeatedly associating S_1 with S_2, S_2 with S_3, S_{n-1} with S_n, have been formed, the highest order so far obtained being the fourth (64–66: 3). C–Rs of higher order have also been reported by forming a C–R to some stimulus after it had been previously associated with other stimuli, as when a C–R was formed to S_2, S_3, and S_4 by first repeatedly associating S_1 with S_2, S_2 with S_3, S_3 with S_4, and then forming a C–R to S_1 (25: 1).

7. Grasping C–Rs have been formed in 4–6-year-old children by having them observe the grasping responses of conditioned children, the C–Rs of the observing children being formed faster when the responses of the conditioned children were reinforced by food (72: 1).

8. Very marked improvements in all phases of conditioning have been obtained by 9-months thyroidization of a 15-year-old cretin, the thyroidization having changed the height of the cretin from 95 to 109 cms. and the ossification from two to nine years (50: 3).

Formation of Simple Positive C–Rs. Speed of Formation.

1. The speed of formation of a simple positive C–R depends, among other factors, upon the nature of the response to be conditioned.[15]

   a. The secretory C–R is less readily conditioned than the motor C–R (36 and T. XLIII: 3).

   b. A response involving wide-spread bodily action (emotional?) is faster conditioned than a response concentrated in fewer effectors (104, 107, 113: 2).

   c. The speed of formation of the withdrawing C–R to shock is more variable than that of other motor C–Rs (T. XLIII: 3).

   d. Certain children failed to form withdrawing C–Rs to shock even after hundreds of trials; these children at times do not give the withdrawing response to the shock itself (82: 3).

   e. The distribution of trials required for formation of the C–Rs is normal for food and verbal C–Rs but very positively skewed for the shock C–R (T. XLIII, Fg. IV–V: 3).

2. The conditioning of the response to the sight of food, itself undoubtedly a conditioned reaction, is not slower in 9–10 year-old children than that of other motor responses which assumedly have not been previously conditioned (response to food in the mouth, shock) (T. XLIII: 3).

3. The speed of formation of the salivary and motor food C–R has been shown to depend upon the age, intelligence (scores on standard verbal, performance, and school achievement tests), physical and mental condition of the subjects, as well as upon the in-

[15] The very slow conditioning of the patellar C–R (11) may hardly be considered final, however, both because of the crude technique and because only two subnormal children were used.

tensities of the conditioned and conditioning stimuli and the intervals between their application.

a. Other things being equal, the older the child the more readily it forms the C–R (96–99: 3).

b. Other things being equal, the more intelligent the child the faster it forms the C–R (96–99: 3; 59–60: 3).

c. Subnormal children form C–Rs more slowly than normal children of the same absolute intelligence (T. XXXV: 3).

d. Attempts to form salivary C–Rs by introducing an acid through a tube kept in the subject's mouth during sleep have failed (Ft. 9: 1).

e. While existing evidence indicates various relationships between speed of formation and mental and physical disorders, it is too meager and varying to warrant a definite statement about the nature of this relationship (46–47).

f. Optimum speeds of conditioning are obtained by optimum ratios between intensities of the conditioned and conditioning stimuli, conditioned stimuli too weak as well as too strong as compared with the conditioning stimuli being less readily conditioned (62: 3).

g. Successive and delayed C–Rs are less readily formed than C–Rs in which the conditioned either precede the conditioning stimuli by short intervals or the two are applied simultaneously (9: 2; 17–18: 2).

4. The speed of formation of a C–R to an electric shock depends upon the age, sex, physical condition, and intelligence of the subject.

a. Children under 14 years form the C–R more readily than older children (T. XXVI: 3).

b. There is evidence that girls form the C–R more readily than boys (T. XXV, T. XXVI: 2).

c. Blind and deaf-mute children form the C–R much less readily than normal children (T. XXIV: 3).

d. Subnormal children form the C–R more readily than normal (T. XXV, T. XXVI: 3).

It will be noted that the relation of age and intelligence to speeds of formation of a C–R with shock as the conditioning stimulus are complete reversals of the relation of these traits to speeds of formation of C–Rs with food as the conditioning stimulus. An explanation for these reversals would plausibly be the greater possibility of "central control," "mental sets," "tendencies," "gestal-

ten," and the like, in shock conditioning. It may well, for instance, be argued that, while older and more intelligent children very readily form C–Rs, they still more readily form "anti-associative" tendencies, new "sets," "gestalten," and the like, an argument apparently supported by the very pronounced skewness of the distribution of trials required for the formation of the shock C–R. However, an examination of the data from which the correlations with age and intelligence have been computed reveals that the norms used in food and shock experiments were not the same—1–2 successive non-reinforced responses in the former, and 4–5 in the latter—and it may thus also be argued that, although the older and more intelligent children in the shock experiments readily formed the C–R they as readily unconditioned it, speed of unconditioning being, as known from the food experiments, positively correlated with these two traits. While strict scientific methodology would obviously forbid recourse to the first explanation before the second is eliminated, the second is somewhat weakened by evidence, too meager to be statistically treated, that even stable food C–Rs are more readily established in older and more intelligent children, and by the greater expectancy of a zero than a negative correlation.

5. The speed of formation in school children of a C–R with words as the conditioning stimuli (incidental association) was shown to depend upon the age of the subjects and upon the method of performing the conditioning reaction.

a. Younger children form the C–R or association more readily than older (87: 3).[16]

b. Active reactions, performed by the subjects at the command of the experimenter, are more readily conditioned than passive reactions, performed by the experimenter's guiding the subject (89: 3).

Stabilization and Dominance of C–Rs.

1. The correlations between trials required for the first appearance and additional trials for stabilization of the grasping C–R are negligible (65, T. XVIII: 2).

2. The withdrawing C–R to shock is less readily stabilized than other C–Rs studied (70, T. XXIII: 2).

3. When applied simultaneously the withdrawing C–R to liminal shock is apparently dominant over the grasping C–R in normally fed 9–10 year-old children (68, T. XXI: 2).

[16] See discussion under shock conditioning.

4. Voci-motor C–Rs to pricking with a needle have been changed into food C–Rs by repeatedly following the pricking with feedings (103, T. XXXIX: 2).

Magnitude, Latency, and Frequency of Occurrence of Simple Positive C–Rs.

1. From their first appearance and until their final stabilization the magnitudes of C–Rs progressively increase, but, up to a certain limit, no significant changes of the magnitude, as a rule, take place in the stable C–R.

2. The relative magnitude of the C–R depends upon the nature of the response conditioned.

The magnitude of the salivary C–R is normally only a fraction of the secretion of the conditioning stimulus (57, T. XIV, XV: 3), but magnitudes fully equal to those of the conditioning responses are not uncommon in other C–Rs (66, 111; T. XX, XLI: 3).

3. The average latency of the food C–R, computed from 83 trials on four children ranging in age from 4 to 15 years, is 4.911 seconds for the salivary and 0.713 for the motor response, with respective S.D.'s of 2.623 and 0.259 (T. XII: 3).

4. The magnitude of the salivary C–R is much more variable than that of the motor food C–R (T. XII: 3).

5. The latencies of the salivary and motor food C–R are much more variable than their respective magnitudes (T. XII: 3).

6. There is a fair negative correlation between the magnitudes and latencies of the salivary and of the shock C–Rs (T. XII, XXIII: 3); the correlations are, however, negligible between the magnitudes and latencies of the motor food and of the grasping C–Rs as well as between the magnitudes of the secretory and motor C–Rs and between the latencies of the secretory and motor C–Rs (T. XII, XXIII: 3).

7. The correlation is also negligible between the magnitude of the salivary C–R and the magnitude of the subsequent conditioning salivation to food in the mouth (T. XIV: 3).

8. The magnitude of the salivary and motor food C–R has been shown to be affected by the age, intelligence, physical and mental condition, and temporary organismic disturbances of the subjects, as well as the diet, extraneous stimulation, nature of the conditioned stimulus, recency of a trial in each experimental session, and intervals between the applications of the conditioned and conditioning stimuli.

a. Statistically reliable results, obtained however from only four children of different ages, would indicate that the magnitude of the salivary C–R decreases with age (T. XII : 3).

b. A fair positive correlation has been obtained between school achievement and the magnitude of the C–R, both absolute and relative to subsequent conditioning salivation (60, T. XV : 2).

c. The evidence for the relation between the magnitude of the C–R and the physical and mental condition of the subjects is too meager and variable to warrant any definite conclusions (48–54 : 2).

d. The magnitude of the salivary C–R is definitely decreased, the C–Rs sometimes completely disappearing, by disease—measles, mumps, scarlet fever and typhoid,—fatigue, visceral tension, and extreme mental excitement or depression (34, 35 : 2).

e. The magnitudes of ordinary laboratory C–Rs are not affected by hypnosis, but suggestion of food, which produces only a fraction of the conditioning response in the normal state, elicits in the hypnotic state salivation fully equal to that of eating food (40, 41, T. IX : 2).

f. The magnitude of the salivary and motor C–R with some food as the conditioning stimulus is definitely decreased after a few days of feeding the subject with only that particular food, the magnitude of the motor C–R being however much less affected than that of the salivary response (32, 33, T. VII : 2), the C–R with other foods as the conditioning stimuli are not significantly affected (32, 33, T. VII : 2).

g. The magnitude of the salivary C–R seems to be decreased by a prolonged protein and increased by a prolonged carbohydrate diet (30, T. VI : 2).

h. The salivary C–R is much more affected by extraneous stimuli than the motor C–R (38, T. VIII : 3).

i. The magnitudes of C–Rs to different stimuli in Krasnogorski's laboratory rank normally as follows: bell, metronome, whistle, electric lamps, tactile stimulation. In as much as these stimuli are not equated for intensity, it is of course impossible to say how much these differences are due to intensities and how much to the intrinsic natures of the stimuli.

j. The relative and absolute magnitudes of C–Rs to different stimuli are often radically changed; this change is asserted to be symptomatic of certain known general organismic disturbances, (46, 47, T. X: 2), but the evidence for the assertion is extremely meager and doubtful.

k. The magnitude of the salivary food C–R declines, as a rule, toward the end of each experimental session (60, T. XV: 3); a fair positive correlation has been obtained between the relative amount of the decline and school achievement of seven children (T. XVI: 1).

l. In C–Rs to chains of stimuli the magnitude of the response to the last stimulus is greater than that to the preceding stimulus (25: 3).

9. The frequency of the occurrence of the C–R to shock is decreased by mental fatigue (mental arithmetic). (86, T. XXIX: 2.)

Experimental Unconditioning of Positive C–Rs.

1. With the exception of C–Rs with words as the conditioning stimuli (incidental association), the repeated administration of the conditioned without the conditioning stimulus results in experimental unconditioning or in a decrement and final disappearance of the C–R.

2. C–Rs with words as the conditioning stimuli (incidental association) do not as a rule become experimentally unconditioned. (88 :3.)

3. Experimentally unconditioned C–Rs are spontaneously restored by periods of no experimentation, but the magnitudes of the restored C–Rs get progressively smaller until finally no further restoration occurs (111, T. XLI: 3).

4. The speed of experimental unconditioning depends, among other things, upon the nature of the C–R.

The withdrawing C–R to shock is less readily unconditioned than the grasping C–R in the same children. (70, T. XXII*b*: 2.)

5. Experimental unconditioning of the food C–R in infants results in the formation of a definite voci-motor avoiding C–R to the conditioned stimulus. (93: 3.)

6. The speed of unconditioning of the food C–R has been shown to depend upon the speed of the formation of the C–R, the age of the C–R, the intervals between non-reinforced applications, as well as upon the age, intelligence, and physical and mental state of the subjects.

a. Fair positive correlations have been obtained between the speed of conditioning and the speed of unconditioning (T. XVI, XXXVI : 2).

b. The older, or the more established, the C–R, the less readily does it become unconditioned (Krasnogorski's and Ivanov-Smolensky's Laboratories, : 3).

c. The shorter the intervals between non-reinforced applications, the fewer the trials required for unconditioning (Krasnogorski's and Ivanov-Smolensky's Laboratories, : 3).

d. Other things being equal, the older the subjects the faster the unconditioning (98: 3).

e. Other things being equal, the more intelligent the subject the greater the speed of unconditioning (60, T. XV: 2).

f. Abnormally slow unconditioning has been reported in certain cases, particularly in subjects of very low mental and physical level (cretins, idiots) (48, Ft. 10: 3).

Retention of C–Rs.

1. No special extensive experiments on the retention of C–Rs over periods of no experimentation have been reported, but retentions of C–Rs without reinforcement for 31 and 49 days, 3 months and 2 years have been noted (104: 2; 111: 2; 52: 2; Ft. 10: 1).

Formation of Negative C–Rs.

1. Negative C–Rs are reported to have been formed in children as young as one year. (93: 3.)

2. Besides the usual mode of forming negative C–Rs by applying repeatedly some stimulus, SS_1, simultaneously with or shortly before the conditioned stimulus, CdS_1, and not reinforcing SS_1 plus CdS_1 with the conditioning stimulus, CgS_1, negative C–Rs to SS_1 plus CdS_1 have also been obtained by applying SS_1 shortly after the beginning of the application of CgS_1 (39: 1).

3. The course of the development of negative C–Rs varies, being sudden in some subjects and gradual in others (65, T. XX: 2).

4. In infants the formation of a negative C–R to food results in the development of a voci-motor avoiding C–R to the negative stimulus. (93: 3.)

5. The speed of formation of negative C–Rs differs on the whole little from that of positive C–Rs (9: 1; T. XVIII: 2), but the correlations between the speeds of formation and stabilization of the two C–Rs are negligible (T. XVIII: 2).

6. The negative grasping C–R to food is less variable in its speed of formation and more readily stabilized than the positive grasping C–R to food (T. XVIII : 2).

7. Certain normal children and, as a rule, children of low physical and mental level (cretins, idiots) fail to form negative C–Rs but develop C–Rs of the second order instead (48, 66, 67: 3; Ft. 10: 1).

This phenomenon is more common in lower animals (fish, amphibia) (Psychol. Bul., April, 1933), while in dogs the kind of C–R formed depends upon the intervals between the applications of the negative and the conditioned stimuli, longer intervals favoring C–Rs of the second order (D. S. Fursikov—Transac. Pavlov's Physiol. Lab., 1925, 1, 1–47). However, the evidence is not sufficiently uniform to warrant any definite conclusions on the relationship between these phenomena and organismic development.

After-Effects and Summation of After-Effects of Negative C–Rs.

1. The application of a negative C–R affects the subsequent positive C–R; this after-effect may be as long as 15 minutes (T. IV: 3).

2. The effectiveness and the duration of the after-effect has been shown to depend, among other things, upon the age of the negative C–R and the similarity—modality, quality, intensity, distance (in tactile conditioning)—between the negative and positive C–Rs.

   a. The older the negative C–R the shorter and the smaller its after-effect (19–21; T. IV, V: 3).

   b. The greater the similarity between the stimuli of the positive and negative C–Rs the longer and the greater the after-effect (27: 2; 19–21: 3).

3. After-effects of the negative C–R are usually negative, causing decrements in the subsequent positive C–R, but the occurrence of positive after-effects—causing increments—has also been definitely established (15–16 : 3; 66: 2).

4. After-effects of the negative C–R become greater by summation, or successive applications of the negative C–R (20, 42: 3).

5. Normally, summation of negative C–Rs results in drowsiness or even deep sleep (42–43 : 2).

6. The number of summations of the negative C–R required to produce sleep on some experimental day has been shown to depend upon the time of the day as well as upon the total amount of general activity of the subjects on that day.

More summations were required in the morning than in the afternoon, and more in the afternoon than in the evening (43: 2); also, more summations were necessary when the subject was blindfolded and still more when he was both blindfolded and kept away from auditory stimuli (43: 2).

7. Excitable children are reported not to fall asleep but to become even more excited by the summation of negative C–Rs (53: 2).

Generalization and Specificity of Simple C–Rs and the Formation of Differential C–Rs.

1. C–Rs generalize to other stimuli of the modality of the conditioned stimuli or even to stimuli of other modalities (Krasnogorski's and Ivanov-Smolensky's Laboratories and Others,: 3).

2. In 7–8-year-old children C–Rs to auditory and visual stimuli generalize to the spoken and printed words "sound" and "light"; similarly C–Rs to the words "sound" and "light" generalize to actual visual and auditory stimuli (72: 1).

3. C–Rs to chains of stimuli give reduced responses when the order of presentation of the different stimuli is reversed (24–26: 2).

4. When a C–R to some stimulus in a chain becomes experimentally unconditioned another member of the chain substituted for it gives a reduced response (24: 2).

5. Pauses and delays of successive and delayed C–Rs respectively become quite specific with training so that the C–R appears only after the particular intervals used between the applications of the conditioned and conditioning stimuli (18: 3; 45: 2).

6. Both positive and negative C–Rs may become quite specific or differential C–Rs formed by the method of contrasts, which in positive C–Rs consist of alternately applying the conditioned stimulus, CdS_1, with and the stimulus to be differentiated, SS_1, without the conditioning stimulus, and in the case of negative C–Rs consists of alternately applying the negative combination of SS_1 plus CdS_1 without and some positive combination SS_2 plus CdS_1 with the conditioning stimulus.

7. Differential auditory C–Rs have been first formed in infants 4 months old and differential visual C–Rs in infants 7 months old (92–94: 3).

8. There is some evidence that the speed of formation of the differential C–R is related to the nature of the C–R, the speed of simple positive conditioning, the speed of negative conditioning,

the age, the intelligence, physical and mental condition of the subjects, but the evidence for the relation between speed of differential conditioning and speed of experimental unconditioning is contradictory.

a. Differential withdrawing C–Rs to shock are less rapidly formed and less readily stabilized than differential grasping C–Rs to food (T. XXII–*a*: 2).

b. The differential secretory food C–R is more readily formed than the differential motor food C–R (13, T. I: 3).

c. A fair positive correlation has been obtained in a small number of cases between speeds of positive simple and differential salivary conditioning (60, T. XVI: 2).

d. There is some evidence for a direct relationship between speed of negative and differential conditioning (Krasnogorski's and Ivanov-Smolensky's Laboratories,: 2).

e. Other things being equal, older children form differential food C–Rs more readily (Krasnogorski's Laboratory,: 3).

f. Other things being equal, the more intelligent the children the faster the formation of the differential food C–R (T. XVI: 2).

g. Children of low physical and mental level form differential C–Rs with great difficulty (49, 53: 3).

9. The course of the development of withdrawing and grasping differential C–Rs is irregular (Fig. I (p. 57) : 3).

10. In positive C–Rs the stimulus to be differentiated, not being reinforced by the conditioning stimulus, becomes negative with the result that the after-effect of its application is similar to the application of a negative C–R (15–16: 3).

11. Infants develop voci-motor avoiding C–Rs to the negative differential stimuli (93–94: 3).

12. Attempts to form differential C–Rs between two closely similar stimuli result in disturbance of the subject's general behavior and the loss of previous differential or even simple C–Rs (44: 3).

13. The degree of similarity between two stimuli which causes disturbances in behavior when attempts to form differential C–Rs are made varies with the physical and mental level of the subject.

In normal six-year-old children tactile differential C–Rs within 3 cms. and auditory differential C–Rs between metronomes of 120 and 144 beats per minute have been developed without any particu-

lar disturbing effect, while in a cretin and an encephalitic subject onsets of "neurosis" were observed upon attempts to form respectively differential tactile C–Rs within 12 cms. and differential auditory C–R to metronomes of 50 and 92 beats per minute (49, 53, 44: 3).

14. General disturbances of behavior have also been observed by delaying more than usual the administration of the conditioning stimulus (45: 2).

15. Finer differential C–Rs and longer delayed C–Rs may more readily be established without ill effects by gradually increasing the similarity and the delay than when the thresholds and the long delays are attempted from the start (44–45: 3).

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APPENDIX

DIAGRAMS OF LABORATORIES AND APPARATUS (EXPLANATIONS IN TEXT)

KRASNOGORSKI'S LABORATORY

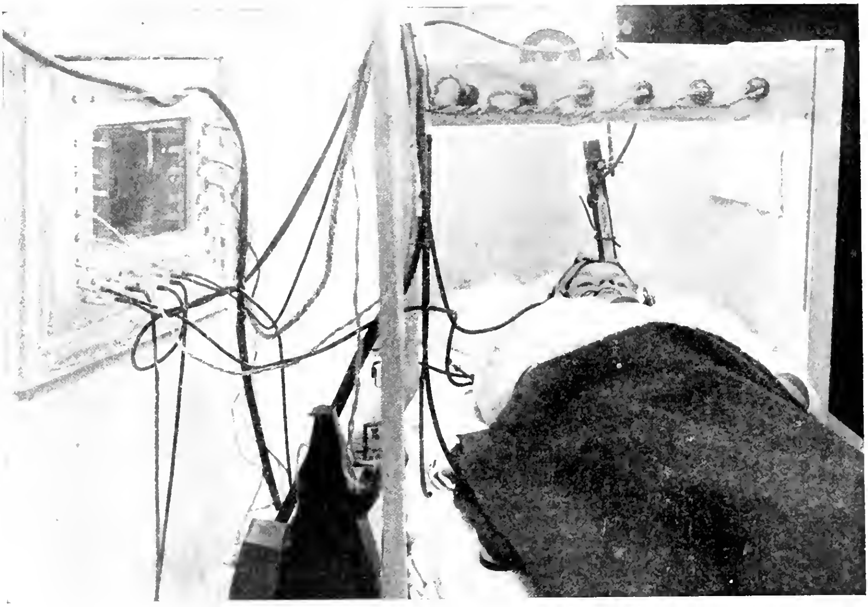

FIG. VII. SUBJECT'S ROOM

(Courtesy Julius Springer. Ergeb. d. inner. Mediz., 1931, 39, p. 631)

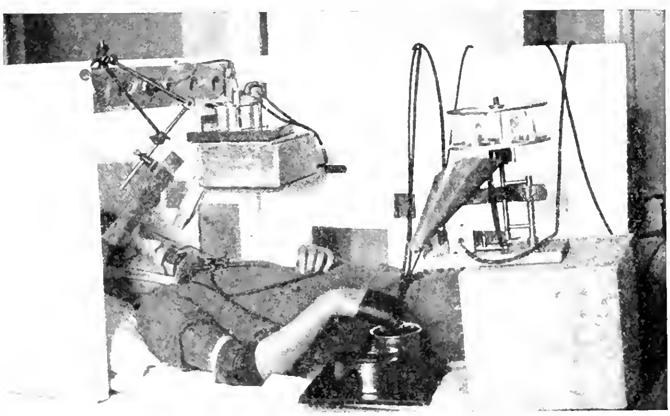

FIG. VIII. CLOSER VIEW OF SUBJECT IN APPARATUS

The Apparatus for both salivary and motor—throat, wrist and arm movement—conditioning is shown; in front of subject—food transmitters.

(Ib. p. 630)

KRASNOGORSKI'S LABORATORY

FIG. IX. SUBJECT WITH CONDITIONING CONNECTING TUBES FOR ALL SALIVARY GLANDS

(Ib. p. 627)

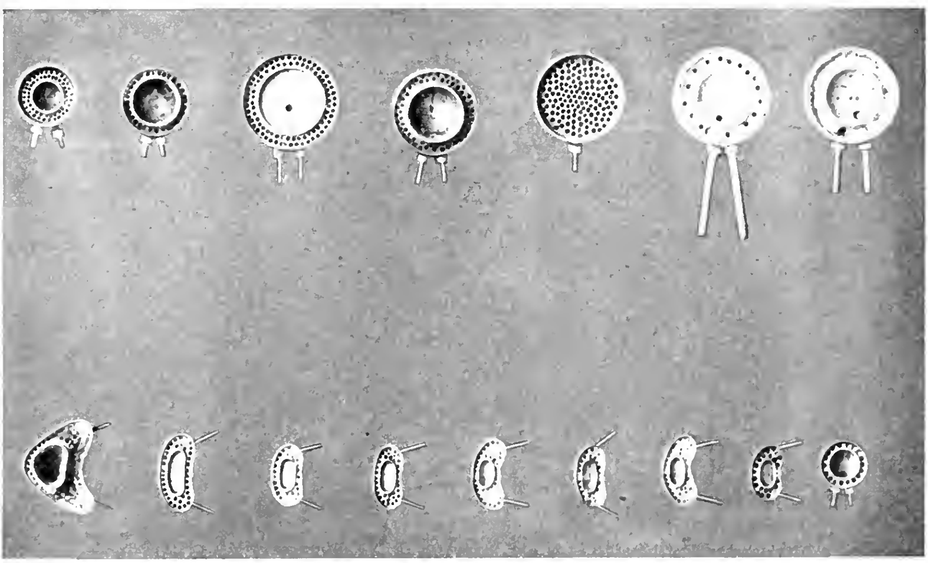

FIG. X. SALIOMETERS: UPPER ROW—PAROTID; LOWER ROW—SUBMAXILLARY.
(Ib. p. 624)

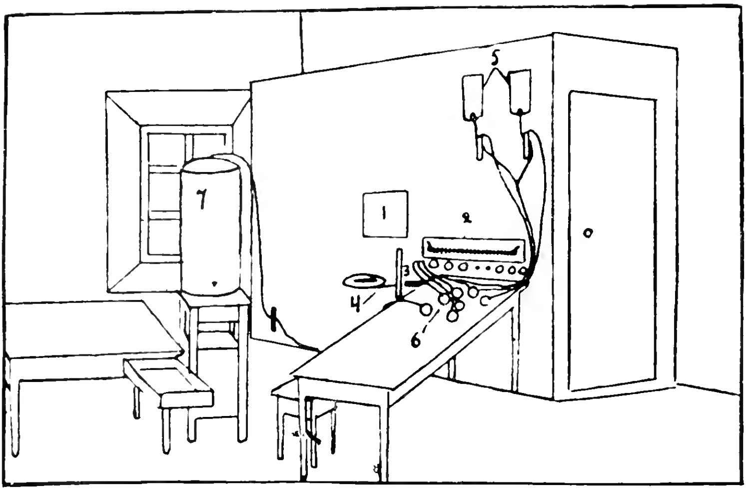

Fig. XI. Experimenter's Room

1—Window for observing subject
2—Recording cylinder with dye
3—Opening for solid food transmitter
4—Solid food transmitter
5—Liquid food and acid bottles
6—Bulbs for activation of stimuli
7—Energy generator

(From Medicobiologichesky Zhurnal, 1927, 3, 112–128)

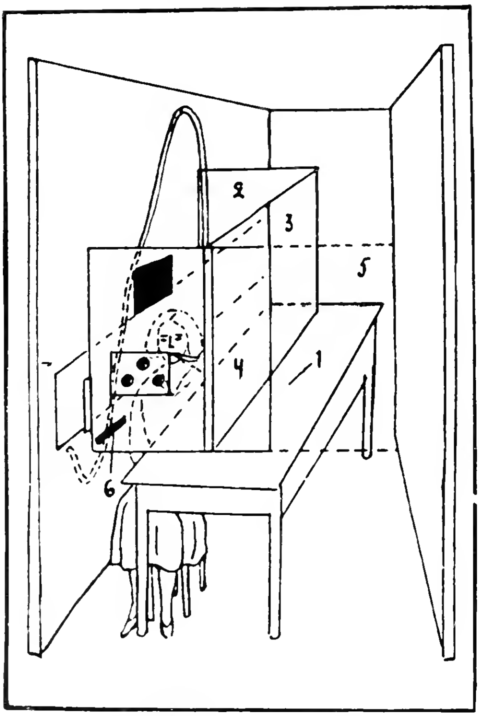

Fig. XII. Subject's Room

1—Table
2, 3, 4, 5—Screens (4 and 5 are hinged)
6—Solid food transmitter

LENZ'S LABORATORY

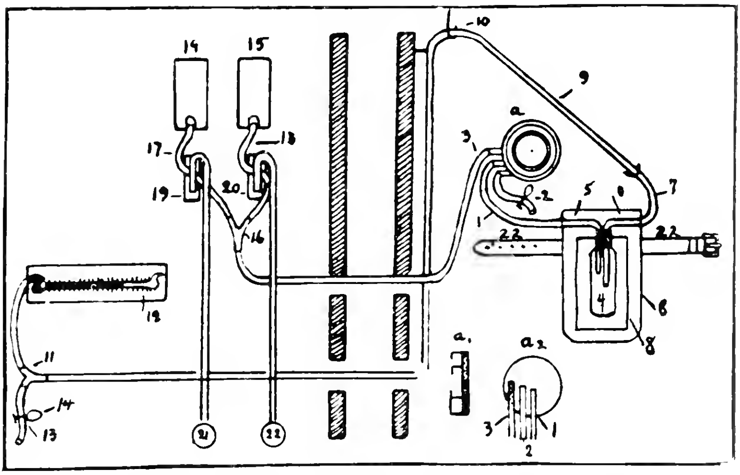

FIG. XIII. COMPLETE VIEW OF THE LENZ LABORATORY
a, a_1, a_2—Saliometers
1, 5—Saliva conduction tubes
2—Suction tube
3, 16, 17, 18—Acid, water, and liquid food conduction tubes
4—Collecting bottle
8—Leather case for collecting bottle
6, 7, 9, 10, 11—Dye displacement tubes
12—Recording cylinder with dye
13—Clamp for regulating recording cylinder
14, 15—Liquid food and acid bottles
19, 20—Clamps for closing food conduction tubes
21—Bulbs for opening bottles 14 and 15
22—Belt for attaching collecting apparatus to subject's neck
(From Medicobiologichesky Zhurnal, 1927, 3, 112–128)

Special Saliometers

Fig. XIV. Submaxillary Saliometer with Separate Connections for Each Duct (Krasnogorski's Laboratory)
(Courtesy J. Springer. Ergeb. d. inner. Mediz. 1931, 39, p. 626)

Fig. XV. Mechanically Held Saliometers (Chuchmarev's Laboratory)
(From Chuchmarev, Z. I. Subcortical Psychophysiology. Kharkov; GIZ, 1928, p. 169)

IVANOV-SMOLENSKY'S LABORATORY

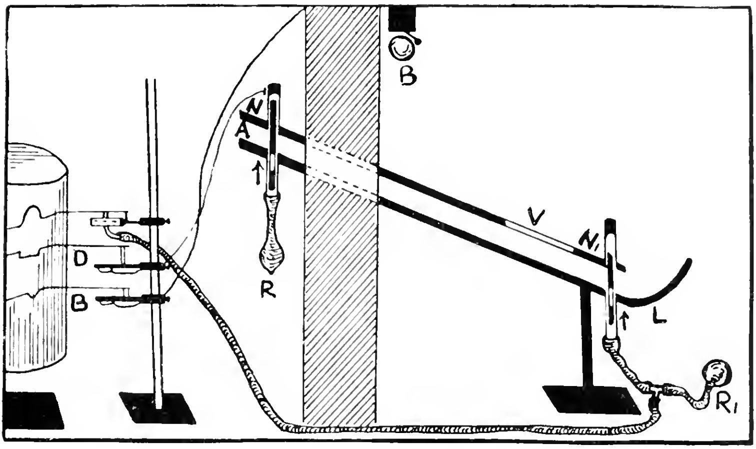

FIG. XVI

NN¹—Sloping metal tube
R—E.'s bulb
R_1—S.'s bulb
V—Glass plate

A—Tube shutter in E.'s room
L—Sloping shelf
B—Bell and its recorder
D—Recorder of E.'s opening and closing tube

(From Medicobiologichesky Zhurnal, 1927, 2, 33–42)

IVANOV-SMOLENSKY'S LABORATORY

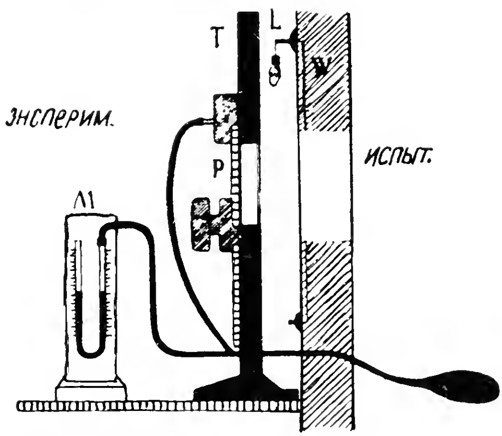

FIG. XVII. CONDITIONING OF THE GRASPING EXPLORATORY RESPONSE

W—Wall
L—Lamp
T—Tachistoscope
P—Shutter
M—Manometer

BEKHTEREV'S LABORATORY

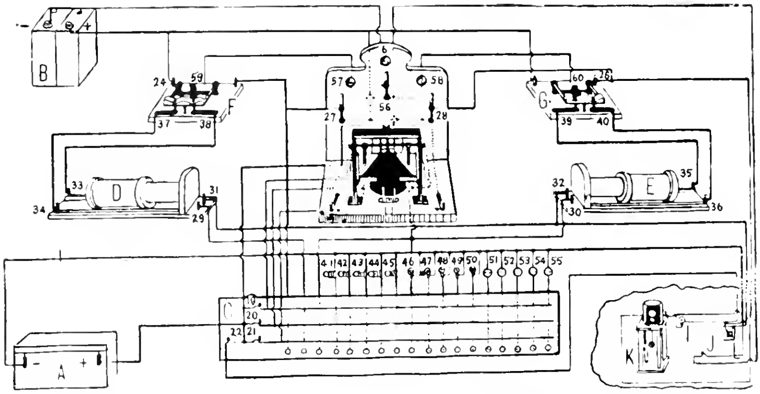

FIG. XVIII. GENERAL DIAGRAM OF BEKHTEREV'S LABORATORY

A, B—Electric accumulators
C—E.'s main keyboard
D—Inductorium for S.'s right hand
E—Inductorium for S.'s left hand
F—E.'s key for S.'s right hand
G—E.'s key for S.'s left hand
H—Time relay

(From Bekhterev, V. M. General Principles of Human Reflexology. Moscow: GIZ, 1928)

BEKHTEREV'S LABORATORY

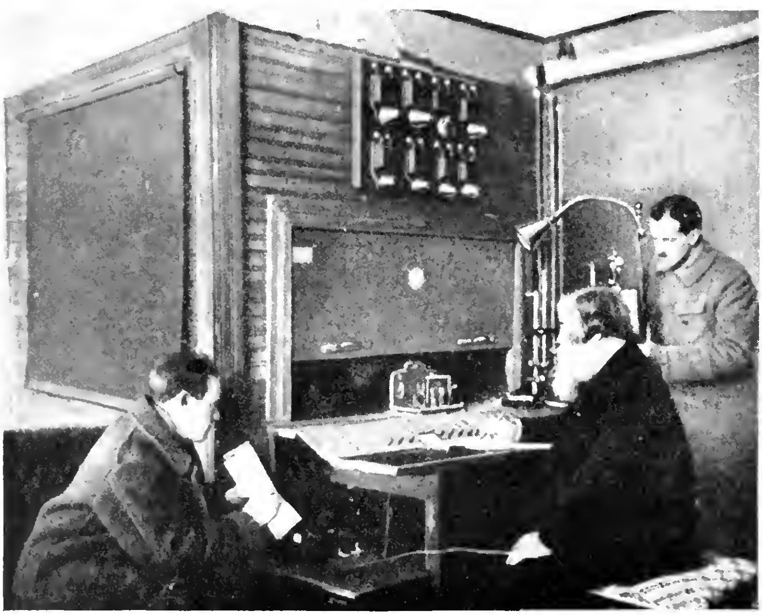

FIG. XIX. EXPERIMENTER'S ROOM

(From Bekhterev, V. M. General Principles of Human Reflexology. Moscow: GIZ, 1928)

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